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EXCERPTS FROM DINNER SPEECH* BY

Major-Gen. Laurence S. Kuter

Commander, Military Air Transport Service

MILITARY planning must be based on fact rather than hope. The future for the next five years is limited by the lack of preparation in the last five years. The future beyond 1955 for great conveyor belts in the air can be rosy indeed if the course is laid out now and all hands get behind and support it.

It is my own conviction that military air transport planning for 1955 for strategic airlift in great volume must be based upon existing aircraft types and types already in or near production and on reasonably fixed and unfortunately limited quantities of those airplanes. I am convinced military air transport planning for 1955 will not be made on the basis of the availability of a measurable proportion of jet transports.

We know what long-range military transports will look like in 1955. They will look very much like the C-97 (Boeing Stratofreighter), the C-124 (Douglas Globemaster), and the C-54 or R5D (Douglas DC-4).

Little Change in 5 Years

You recall that the Douglas C-54 and C-54A were first flown in 1942. Even under the intensive stimulation of war, it was four years later, in 1946, that we climbed through the alphabet—skipping very few letters—from the C-54A to the C-54M. The C-54M looked exactly like and performed in general accord with the original C-54.

The first YC-97 was delivered to the Air Transport Command in 1947. Two model C-97As were de-

* Dinner speech "The Transport Airplane as Related to Future Military Plans" was presented at SAE National Aeronautics Meeting, New York, April 19, 1950. (This speech is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

livered to MATS in 1949. More C-97As are now on order and will be delivered through 1951. It is not unreasonable to assume that C-97Ms will be new in 1955 but that they will look like the C-97A.

The first Douglas C-124 will be delivered to the Air Force in 1950. We may be getting C-124Ms in 1955, and they will look like C-124s. The performance of the eventual C-97 and C-124 can, however, be appreciably superior to the 1949 models due to use of new types of powerplants, such as turboprops. In addition, we can be quite sure that in 1955 there will still be flying, as second-line military transports or in civilian dress, considerable numbers of C-54s, the latest type of which will then have reached the ripe old age of nine years.

Airlift Available Now

We can be almost as precise with regard to the quantity of the lift available for military planning in 1955. As of April 19, 1950, MATS had a total strength in four-engine transports of 241 Air Force C-54s, 27 operational Navy R5Ds (plus maintenance and reserve to support their operation at six hours per airplane per day), 10 C-121s (Lockheed Constellations), 10 C-74s, and 7 C-97s. Our total number of four-engine transports in MATS equalled 295.

MATS present total of four-engine aircraft, just under 300, is most unlikely to be exceeded in 1955. The current policy of the Department of Defense does not envisage any increase of our numbers of four-engine transports. Defense policy is to procure transport aircraft for the military services in peacetime as replacements to maintain the authorized strength of the military air fleet.

Present policy of the Department of Defense provides that efforts will not be made through military procurement to reduce the anticipated national wartime deficit in the total numbers of American civil and military transport airplanes. The reason for this policy is that the addition of transport aircraft to the present military fleet other than as replacement for existing aircraft would cause peacetime military transport capabilities to exceed peacetime requirements.

I must emphasize, however, that a substantial increase in available military airlift will accrue by 1955, although the numbers of military airplanes are not increased. It is the policy of the Air Force to replace as rapidly as funds permit the authorized number of C-54s in MATS with modern heavier type transports on a one-for-one basis. The transports now being procured to replace the C-54s are of modern heavy types, C-97s and C-124s, which will provide much greater capabilities per airplane in terms of ton miles. For every C-54 that is replaced by a new heavy transport, the capability of that unit goes up roughly three times. Thus, when the C-54 transports now in the Military Air Transport Service's regular training fleet are all replaced by the new types, we will have in operation the equivalent of something less than 900 C-54s.

Military planning for 1955 must take into consideration the airlift potential of all of the four-engine transports of all of the civil air carriers of the United States. We hope that the civil domestic two-engine fleet will be adequate to serve the wartime domestic economy. If the two-engine fleet should prove inadequate to meet domestic requirements in time of war, those of us in uniform will be the first to insist that four-engine transports be diverted from strategic long-range use to meet those long-haul domestic requirements which are obviously essential to the national effort in wartime.

The civil operators have indicated they are ready and eager to support the military beginning on D-Day. However, all agree that there are definite limitations on their immediate usefulness. Two basic characteristics will be required of strategic transport aircraft on D-Day. These are long range and ability to carry cargo.

A recent on-the-spot survey of the airlines by representatives from MATS showed that only 25% of the four-engine aircraft of the civil fleet are capable of carrying cargo and only 10% are cargo carriers capable of satisfactory military range performance; that is, 2500 non-stop miles.

To complete the statement, however, operational factors show that more than 50% of the four-engine civil fleet could be made theoretically available to the military on D-Day and within one week almost 95%. I must stress that I am speaking of availability of the airplanes and not of their immediate adaptability to effective military use. Entirely on the credit side is that fact that the skills of the civil carriers developed through years of operation should serve to maintain high operating efficiency. Their maintenance facilities are capable of 100% expansion.

It is not possible now and may never be possible to determine exactly what proportion of the long-range civil aircraft will be available in uniform for strategic airlift in the next war. It is expected that in the next emergency a high governmental authority will control the allocation of civil transport aircraft to civil or military functions. Eminent civil authorities have recently estimated that 35 to 65% of the four-engine fleets of U. S. civil operators will be required within the domestic economy in wartime.

Total Lift Available in 1955

As of March 1, 1950, the total four-engine civil commercial fleet of all U. S. civil air carriers represents 891 or just under 900 C-54 equivalents. The current health of the business, while not discouraging, cannot be accepted as evidence that existing markets will bear any great increase in the capacities of those particular civil air transorts. (Even if prototypes, designed for much more economical operation to tap new and much greater markets, were in production in 1950, there would be little actual increase in available physical capacity by 1955.) Consequently, we must accept the fact that the long-range civil commercial capacity of the U. S. operators will not be greatly increased by 1955 beyond the present 891 equivalents, of which 100 or 65 or 35% may be available for strategic military use. The grand total of U. S. four-engine aircraft which can influence military transport planning in 1955 is around 1800 C-54 equivalents.

Since the Air Transport Command alone at its peak strength in July of 1945 operated 3000 transport airplanes (admittedly of two- and four-engine categories), it seems obvious that the types and numbers of transport airplanes which will be available to influence military plans in 1955 do not, to

say the least, offer a wealth of resources to the military planners of the future.

Beyond 1955 we know that the future can be rosy indeed, but only if essential preliminary actions are taken now.

A military policy has been established and the Air Force has on order high capacity replacements which are already increasing the capability of the military component of this civil-military national resource. I believe that the military has been doing and will continue to do its part toward this national end.

Aid for Civil Fleet

On the civil side, the President's Air Policy Commission three years ago under Mr. Finletter determined that the soundest way to build up a pool of cargo planes for an emergency is to develop a cargo plane that can operate on a profitable basis. The Commission recommended creation of an Aircraft Development Corporation to develop such an all-cargo transport useful to the military, but designed primarily for economic commercial operation. This action on the civil side has not been accomplished.

Following the Finletter Commission, the Congressional Air Policy Board under Senator Brewster and Representative Hinshaw two years ago recommended that the Federal Government should sponsor the design and development of prototype transport and cargo aircraft intended primarily for commercial use, but suitable for certain military purposes. The Board advised that funds be allocated to the Air Force and earmarked for this specific purpose.

In line with this Congressional Air Policy Board recommendation, the military, in cooperation with the civil operators, have laid down general specifications for long-range, medium, and short-haul transports.

Numerous bills bearing on prototype legislation have been before the current Congress since it convened. None have been enacted. The previous Congress had substantially the same bills before it on which no action was taken. The Congress before it enacted no prototype legislation.

I believe that the greatest single obstacle to the development of new and more economical types of transport aircraft and the assured expansion of the size of the American civil commercial fleet has been the existence of inconclusive legislative proposals. The manufacturing industry and the operators have not invested their own funds in such projects while the provision of Federal funds has been under consideration. As long as Federal funds are in the offing, I believe that it is unnatural to expect any single American manufacturer to risk his private funds on such a project.

Early in February 1950, it was announced that the program of the President did not include the provision of Federal funds for the design and development of new transport types but could provide funds for a limited flight and operational testing program under a civil agency for such civil aircraft as might otherwise be made available. After the receipt of that decision, the President's Air Coordinating Committee endorsed and submitted to the Bureau of the Budget draft legislation to accomplish those portions of the prototype program which are in accord with the program of the President.

The Air Coordinating Committee has discussed this legislation with the president of the Aircraft Industries Association, Admiral Ramsey. He stated that from his viewpoint it is far from a complete solution to the prototype problem, but concluded that it has value in the encouragement of the conversion of existing types and models to turbine propulsion and that the provision of government assistance to take care of certification tests should be of real value and should hasten the day when American turbine-type airliners are available for delivery to the airlines. He further concluded, "So, taken all in all, the Aircraft Industries Association wholeheartedly supports the bill."

The Air Coordinating Committee discussed that legislation with the president of the Air Transport Association. Admiral Land's conclusion, generally in line with Admiral Ramsey's, was expressed with his characteristically salty force and clarity to the effect, "It is clear that we will get this bill or nothing and that we will get it now or never. All hands must therefore get behind and support it."

The Administration, all executive agencies of the Government involved in civil aviation, the Aircraft Industries Association and the Air Transport Association are supporting this legislation. Therefore, there seems to be more likelihood of the enactment of this bill or some other prototype bill *or a negative decision* by this Congress than has been the case when the previous Congresses were confronted with divided views and with varying degrees of support by the same governmental and civil agencies.

Lack of Jets Hurts Pride Only

For the next five years or so, assuming, of course, continuance of the Cold War, we can anticipate no substantial change in the influence of air transportation on military plans. There will be no substantial change because no substantial change has yet been initiated. In balancing vision against industrial fact, we find no "whoosh" in our military transport plans for 1955.

With specific reference to the jet transport, the British and the Canadians laid down the Comet and the AVRO C-102 in 1946. As far as we know, there are only one Comet and one AVRO C-102 in operation in 1950. Debugging those prototypes will take some time before even modest quantities of such aircraft could be placed in production, if it is found to be economically feasible with presently available jet power to undertake even modest quantity production.

As to national pride and prestige, we are perturbed to see any other nation, even our close friends in Canada and England, flying newer transports than we are making. To date and until much more development of large jet propelled aircraft of bomber types, I believe that it is only our pride and our prestige that are hurt. As far as military plans are concerned, we want to see a lot more flying by jet bombers before hoping for substantial quantities of jet transports. We are not laying military plans on any presumption that the economics of air transport will support a measurable proportion of jet transportation until sometime after 1955.

AUTOMOTIVE

BASED ON PAPER* BY

A. J. Carter

Assistant Department Head
Rubber & Plastics Laboratory
Chrysler Corp.

THE varied properties required of a brake lining material calls for careful selection and blending of its ingredients.

Lining requirements are:

1. Correct coefficient of friction, which is influenced by temperature reaction, aging qualities, water reaction, and oil and grease reaction;
2. Durability;
3. Relative freedom from any tendency to score drums;
4. Quietness in operation; and
5. Nonoffensive odor.

Lining friction coefficients generally run between 0.20 and 0.40. Manufacturers usually describe linings as having high, medium, and low friction coefficients without specifying friction value numerically. It's not hard to compound a lining with an initial specific friction coefficient; but to produce a lining with uniform braking performance under various operating conditions takes much compounding study and laboratory and road testing.

The ideal lining would have a constant friction coefficient at high and low temperatures, under wet and dry conditions, throughout the lining's life. There is no such lining. All linings disintegrate under high braking temperatures. Chemical and physical changes either increase friction coefficient (build-up) or decrease it (fade).

With fade, if friction characteristics return to their initial condition, the lining is said to have good recovery properties. Satisfactory linings fade slightly with each brake application, but recover immediately after cooling. Linings producing build-up in friction coefficient are not satisfactory.

Friction coefficient may increase or decrease with age. When it decreases, it develops a hard pedal. Some linings harden and tend to score drums and be noisy.

Other linings are sensitive to water on the friction face, with effects as pronounced as those from temperature. Moisture also causes "morning sickness." Iron oxide forms on the drum and gives high friction reaction during the first two or three stops made after the car has been parked over night. Because of contact with oil and grease in service, linings should have some resistance to these materials.

Linings also should wear slowly and uniformly. This insures more consistent braking action by continually renewing the friction surface. Negligible wear may produce a glazed friction surface.

Certain ingredients tend to score drums. Steel drums score more readily than cast-iron ones. Brake system quietness is a function of the lining as well as other factors. Ingredients must not produce offensive odors at high braking temperatures. Good compounding ingredients may be discarded because of this limitation.

Brake lining materials derive their properties from fillers, binders, and wear-enhancing ingredients, such as those in Table 1. Selection and percentages of ingredients used varies with the type of lining.

Chief lining constituent is Chrysotile asbestos, used as the primary reinforcing material. Chemically, it is an hydrous magnesium silicate ($H_4 Mg_3 Si_2 O_9$). The mineral fibers are 1/8 to 6 in. long. Under high magnification the fiber looks like many finer crystalline threads bundled together. Diam-

* Paper "Automotive Brake Lining Materials," was presented at SAE Annual Meeting, Detroit, Jan. 13, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Table 1—Brake Lining Ingredients

Binders	Fillers: Reinforcing	Fillers: Nonreinforcing	Friction Modifying and Wear Enhancing Agents	Curing Agents and Accelerators
Elastomers	Chrysotile Asbestos	Barium sulphate	Cashew nut liquid products (powders)	Standard rubber and resin primary and secondary curing agents and accelerators
Rubber		Calcium sulphate	Rubber and synthetic rubber	
GR-S		White lead	Ground rubber tire scrap	
Buna N		Lead carbonate	Iron oxide	
Neoprene		Clay	Metals—lead, zinc, brass	
Phenolic resins		Asbestine	Lead salts	
Oil modified phenolic resins			Talc	
Cashew nut oil resins			Graphite	
Drying oils			Bituminous materials	
Sulfurized oils			Abrasives	

BRAKE LINING MATERIAL

Ingredients Hold Key To Service Behavior

eter of the smallest fiber which can be separated is about 0.00003 in.

Asbestos makes a good friction material because of its heat resistance, chemical resistance, flexibility, low thermal conductivity, and hardness. Its reaction to heat is particularly important.

The asbestos fibers start losing their water of crystallization at about 600 F. The loss rate increases with temperature and become rapid at 1000 F. When the water is driven off, asbestos looses its crystalline properties and becomes a powder. Asbestos fiber breakdown to powder with heat makes possible rejuvenation of the lining's friction surface. Today's brake linings would be impossible if heat generated in braking a car decomposed only organic materials and changed asbestos into a hard, organic fused layer of abrasive material.

Poor heat-conducting properties of asbestos help keep heat from penetrating deeply into the lining. This would produce chemical changes in binder materials and would harm lining friction characteristics.

Asbestos fabrics have a friction coefficient of about 0.35. This is within the 0.2 to 0.4 range around which satisfactory braking systems have been designed.

Brass, lead, or lead alloy wires used in woven materials strengthen the yarn. Some claim lead surpasses other metals because it stabilizes the friction coefficient, acts as a dry lubricant to prevent drum scoring, and inhibits formation of abrasive particles on the friction surface.

Metallic powders, such as zinc and lead, improve performance at high temperatures. Limitation with fine lead is that it oxidizes easily to litharge, which promotes oxidation in unsaturated organic compounds. Some believe these powders help break the continuity of the friction surface film during braking action. Large amounts of metal (40%), such as brass chips, are added to linings for very high temperature requirements.

Brake lining compounders also add lead to compositions in the form of organic salt. High temperature liberates it as finely divided lead in a reducing or inert atmosphere. This prevents oxidation of the metal to an oxide and permits it to function as a friction stabilizer.

Graphite in lining compounds imparts a lubricating effect for smoother stopping. It can be incorporated in the hard rubber or added separately. Some compounders see two advantages for graphite encased in rubber. First, it does not interfere with flow of the resin binder during curing. Second, graphite is released for its lubricating action only after the rubber is softened by high braking temperature.

Iron oxide in small amounts sometimes is used as a friction-controlling element. It tends to have a self-polishing action which partly controls surface frictional properties.

The compound usually requires large amounts of inorganic fillers to produce frictional effects. This necessitates an improved friction stabilizer that functions over a wide temperature range. Organic modifiers—such as rubber, ground rubber scrap, pitches, and gilsonite—function best over narrow temperature ranges.

A powdered product made from cashew nut liquid is one of the better friction-stabilizing and wear-enhancing agents used today. This material works satisfactorily up to temperatures of 600 to 650 F. Tire scrap particles function up to about only 500 F. About 6 to 8% of dust is needed to improve wearing qualities.

Ground-rubber tire scrap has been, and will continue to be, widely used because it is a cheap raw material. Other friction modifiers—such as pitches, gilsonite, coal, and petroleum coke—can be used in limited quantities only because of their low temperature resistance. Braking temperatures destructively distill these materials to form tarry or pitchy residues at the friction surface. These increase the friction coefficient at low temperatures. But at high temperatures, volatile materials may be driven off too rapidly before formation of tarry products, losing their effectiveness.

Research today is aimed at getting binding materials with high heat resistance. Currently the

Fig. 1—As this brake shoe shows, bonded lining makes available twice the usual lining and virtually eliminates drum score

Lists New Need With Bonding Lining

Add bondability as a sixth lining requirement, advises S. G. Tilden, The Permafuse Co. The advent of bonded brake linings makes this a must.

Tilden's organization has set up an arbitrary minimum bond strength requirement of 600 psi in shear. This gives a total shear strength of 11,500 lb on a $1\frac{3}{4} \times 11$-in. segment. That is about five times the maximum shear force exerted on linings by a simulated emergency stop with a 1 g deceleration.

All lining factors producing good bondability have not been established. But tests have been made to find the effect of porosity. Strangely enough, denser and less absorbent linings bond better.

Bonding suitability also calls for availability of the entire lining thickness for use. That's why wire-back linings are not suited for bonding. They can be used only down to the wire backing; after that they score the drums. With wire backing, the promised double wear from bonded linings cannot be realized.

Typical of the extra wear available with bonded lining is the lining in Fig. 1. This brake shoe with bonded lining was used until the segment had worn completely through to the shoe at the central tangential area. Note the lack of drum score, except for the lower edge portion; this came from actual metal-to-metal contact between brake shoe and drum.

Tilden points out that bonded linings also improve the path for conducting heat into the brake shoes, backing plate, and axles. It provides a bridge without the insulating air layer usually present in riveted linings.

main binding agents are synthetic resins, drying oils, rubber, and bituminous materials. Most important group is the synthetic resins. Oil modified phenolics are mostly used. Synthetic resins hold much promise because they can be synthetized in the laboratory to meet desired binding material requirements.

Available resins vary in their properties. Some can be used alone, others must be used together with natural, synthetic, or reclaimed rubber. Oil modified types also are commonly used with these rubbers.

Used as a binder, rubber or GR-S must be vulcanized to function properly. In lining compositions they usually are cured to a hard rubber with 25 to 40% sulfur as the vulcanizing agent. Their relatively low softening and decomposition temperatures limit rubbers alone as binding agents. In the future it may be possible to synthetize rubber polymers that will make satisfactory brake lining binding materials. Some day special rubbers may be expressly made for this use.

Drying oils, used for many years in brake lining formulations, are limited because of control of polymerization (hardening). They are used in air-curing type and woven linings. Wide use also is made of them as a binding component in modifying phenolic resins.

(The paper also tells how fabric and molded linings are made.)

Four Factors Influence ENGINE DEPOSITS

Excerpts from Second Report* of the Engine Varnish and Sludge Group, Motor Fuels Division, Coordinating Fuel and Equipment Research Committee of the Coordinating Research Council, Inc.

by Harold J. Gibson

Leader of the Group's Analysis Panel and Research Coordinator, Ethyl Corp.

The earlier report, "Study of Varnish and Sludge Tendencies of Fuels," from the CRC Engine Varnish and Sludge Group appeared in SAE Quarterly Transactions, Vol. 2, No. 1, January, 1948.

THESE four factors have major effects on the formation of engine deposits:

1. Engine design
2. Fuel characteristics
3. Lubricating oil characteristics
4. Operating conditions

No one of the four factors can be singled out as always being most important in formation of sludge and varnish.

These conclusions were deduced from private and cooperative field data obtained through the efforts of the Engine Varnish and Sludge Group and the Sulfur in Motor Gasoline Group of MFD.

Also, comparison of piston skirt varnish data from the field tests with others from laboratory FL-2 tests indicated that the FL-2 skirt varnish rating does not predict the varnish-forming tendencies of all fuel-lubricant combinations in all types of service. (When the effects of engine design and operating conditions are taken into consideration, it would indeed be surprising if correlation were good.) However, FL-2 ratings appear to place combinations of fuels and lubricants in the same order as their average road performance in engines sensitive to fuel quality.

Discussion of field tests, plots of sample data, and conclusions follow.

* Paper "Engine Varnish and Sludge" was presented at SAE National Fuels and Lubricants Meeting, St. Louis, Mo., Nov. 4, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

1. Effect of Engine Design on Deposits

A number of laboratories employed different makes of vehicles in individual field tests in which all other conditions were essentially the same. Two comparisons were also available from the Sulfur Group tests.

Fig. 1 presents a number of comparisons of piston skirt varnish formation in Engines A, B, and C, which are used in the three popular low-priced cars. In Laboratories 1, 3, and 5, and the Sulfur Group tests, Engine A was consistently cleaner than B. This relation was reversed by Laboratory 9, indicating that relative design effects can be reversed

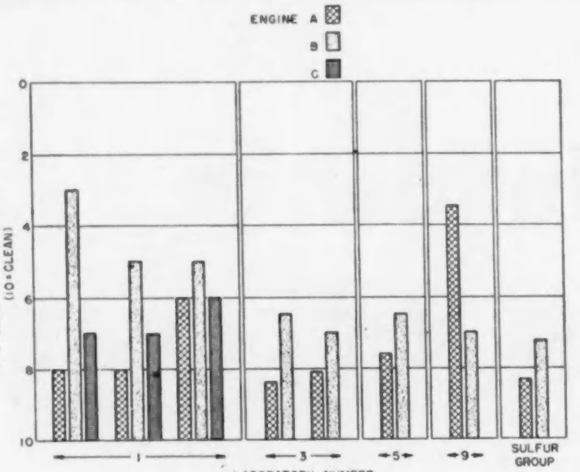


FIG. 1 THE EFFECT OF ENGINE DESIGN ON PISTON SKIRT VARNISH.

PASSENGER CARS IN NORMAL SERVICE
ALL COMPARISONS BASED ON SAME FUEL, OIL, AND TYPE OF OPERATION

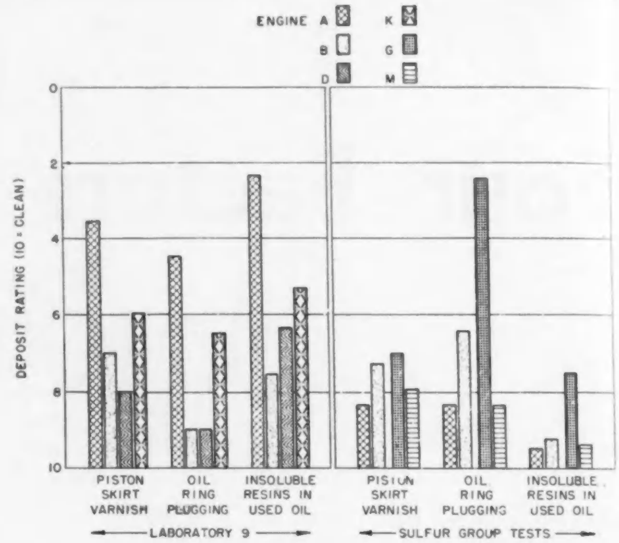


FIG 2 THE EFFECT OF ENGINE DESIGN ON PISTON SKIRT VARNISH, OIL RING PLUGGING, ANC INSOLUBLE RESINS IN THE USED OIL.

ALL CONDITIONS FOR ENGINES REPRESENTED BY GROUPED BARS WERE COMPARABLE

by combinations of fuels, lubricants, and operating conditions.

Fig. 2 further illustrates the large effects of engine design on deposits as reflected by such inspection items as piston skirt varnish, oil ring plugging, and insoluble resins in the used oils. These comparisons are based on data reported by Laboratory 9 and data from the Sulfur Group tests. It will be observed that there was a large effect of design on each of the three inspection items. Data from Laboratory 9, on Engines A, B, D, and K, put all these items in the same relative order; that is, when skirt varnish was heavy, ring plugging and insoluble resins were both high. This same consistent relation is apparent in the Sulfur Group data for Engines A and B, although the ratings for the two engine makes are reversed relative to those from Laboratory 9. Engine G is apparently much more susceptible to ring plugging than Engine M at the same level of varnish formation. Although Engine G was dirtier than M in every respect, the large difference in piston ring plugging may well be largely a matter of ring design.

Fig. 3 shows the effect of piston oil ring design on plugging in trucks in heavy-duty, cross-country operation using three different combinations of oil and gasoline. The range is about as great as was obtained in the same operation by wide variations in quality of fuels and lubricating oils.

Other data showed that oil filters may help considerably in reduction of varnish and sludge deposits.

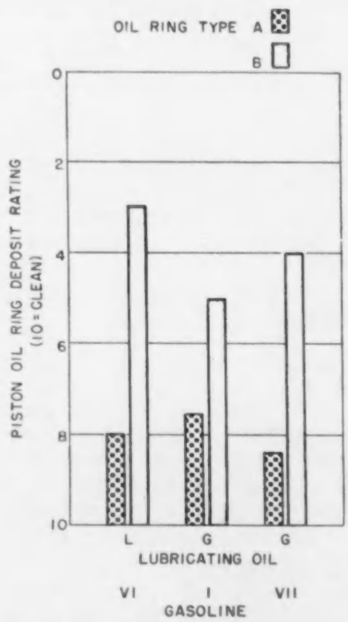


FIG. 3 THE EFFECT OF DESIGN ON OIL RING PLUGGING.

THREE DIFFERENT COMBINATIONS OF LUBRICATING OIL AND GASOLINE ENGINE F IN 6000 MILE TESTS IN HEAVY DUTY TRUCKING OPERATION.

Conclusion—Engine design, as exemplified by different makes of engines or by modifications of a given engine, is important in the formation of

sludge and varnish. Engines vary significantly in level of requirement with respect to quality and in sensitivity to change in quality of both fuels and lubricants. It is probable that there is similar variation in sensitivity to change in operating conditions.

2. Effect of Oil Characteristics on Deposits

Fig. 4 presents a comparison of the effects of straight mineral oil and Specification 2-104B heavy-duty oil on piston skirt varnish in three different makes of passenger car engines (the three low-priced cars) used in normal service. It will be observed that on the basis of piston skirt varnish, the additive oil was better in Engine A, slightly worse in Engine B, and considerably poorer than the straight mineral oil in Engine C. The additive oil was slightly better on a total-deposit basis in all engines. This serves to emphasize the marked effect of engine design, not only on the formation of engine deposits, but on the relative performance of lubricating oils.

Fig. 5 is based on tests under carefully controlled conditions and shows that the effect of lubricating oil on cleanliness is affected by the fuel on which the test is run. Fuel L was quite clean, so that the 2-104B oil kept the engine at a very satisfactory level of cleanliness, while the Regular Type oil kept the engine only moderately clean. With Fuel W, a very dirty fuel, the 2-104B oil reduced piston skirt varnish formation but made no significant improvement over the Regular Type oil in the oil screen or piston oil ring cleanliness.

Conclusion—Lubricating oil has a significant effect on engine cleanliness, the magnitude of the effect depending on the level of deposition caused by the other three factors. Under conditions sensitive to lubricating oil quality, the effect on deposits appears to be of magnitude similar to that caused by variation in fuel quality, under conditions similarly sensitive to fuel. Short oil change periods tend to minimize differences in oils in service.

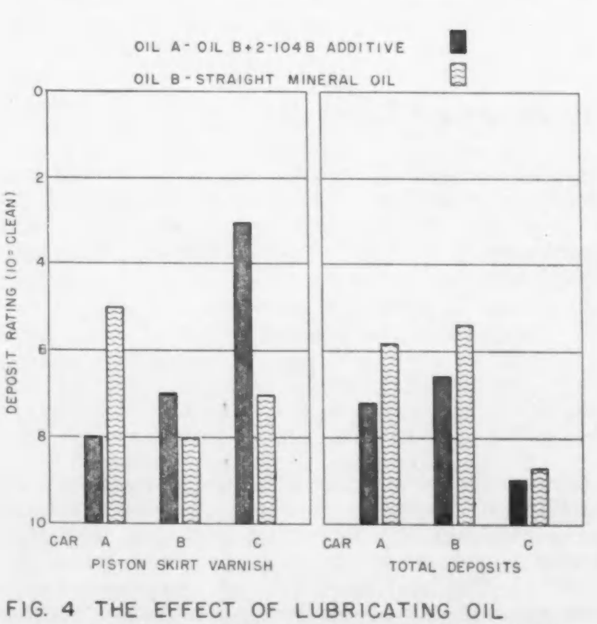


FIG. 4 THE EFFECT OF LUBRICATING OIL CHARACTERISTICS ON ENGINE DEPOSITS.

THREE DIFFERENT PASSENGER CARS IN NORMAL OPERATION FOR 5000 MILES WITH NO OIL CHANGE

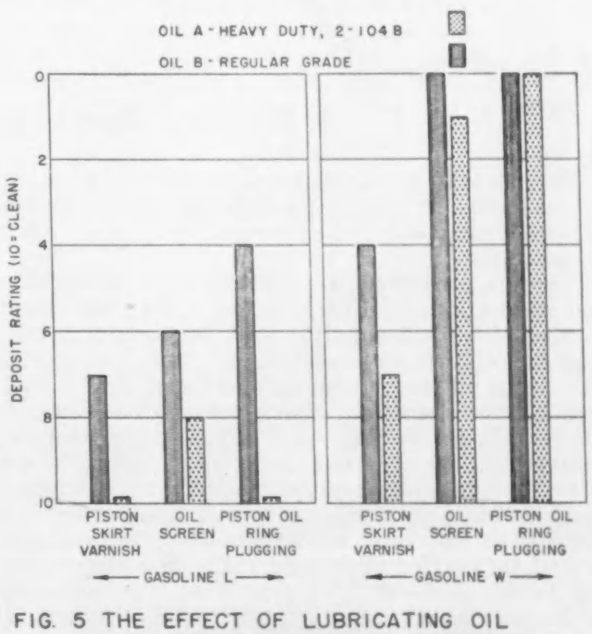


FIG. 5 THE EFFECT OF LUBRICATING OIL CHARACTERISTICS ON ENGINE DEPOSITS.

TRUCK, MAKE F, IN MEDIUM TO HEAVY DUTY, CROSS COUNTRY OPERATION FOR 35000 MILES.
OIL CHANGED AT 2000 MILE INTERVALS.

3. Effect of Fuel Characteristics on Deposits

Fig. 6 shows a range from dirty to clean due to change in fuel quality alone in a given engine make. Clean fuels do not necessarily insure clean engines, however, since combinations of the other factors in cleanliness may mask fuel effects. For example, oil oxidation may be so severe that fuel effects on deposits are hidden completely. The reverse may be equally true, of course.

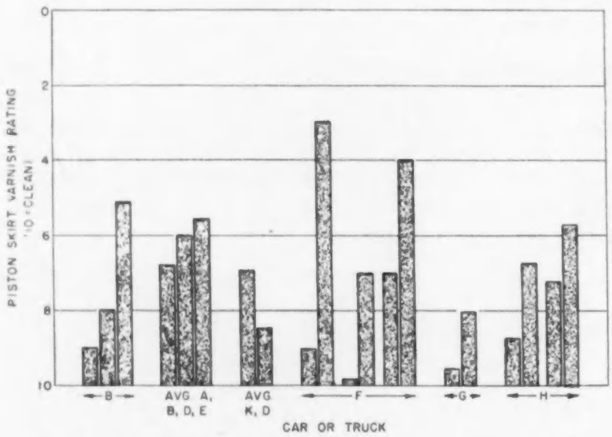


FIG. 6 THE EFFECT OF FUEL CHARACTERISTICS ON PISTON SKIRT VARNISH.

ALL CONDITIONS COMPARABLE FOR ANY ONE COMPARISON. EACH COLUMN REPRESENTS A DIFFERENT FUEL.

CAR OR TRUCK	OPERATION
B, D, E, K, D	PASSENGER CARS - NORMAL
F, G	TRUCKS - HEAVY DUTY
H	TRUCK - DOOR TO DOOR DELIVERY

A series of tests by Laboratory 5 indicated that sulfur content of the fuel is not necessarily a factor in engine deposits, since RMF 52-47 (a research motor fuel) containing 0.28% sulfur gave just as good results on the road as did RMF 53-47, containing 0.046% sulfur. Many more data on this subject will be available when the report covering the field tests conducted by the Sulfur Group is published. Data presented by Laboratory 9 indicated that piston ring wear was less with a fuel which does deposit varnish than with a fuel which left the engine clean.

■

Conclusion—Fuel characteristics are important in the cleanliness of the sensitive engines but of relatively little importance in the insensitive engines. There is as yet no recognized inspection test which will predict the tendency of a fuel to form varnish or sludge in engines.

4. Effect of Operating Conditions on Deposits

The material made available for the preparation of this phase of the report included only information which had been presented in various technical publications.

There is general agreement among investigators that door-to-door delivery service is the most severe type of operating conditions so far as sludge and varnish deposits are concerned. The low cooling jacket and oil temperatures, and the protracted periods of idle operation, which are characteristic of this service, frequently cause engine difficulties and possible failures after only a few months and at low mileage. Lubricating oil becomes loaded with contaminants in a very short period of time.

Remedies for these conditions are chiefly higher oil and jacket temperatures and adequate crankcase ventilation—with emphasis on the necessity for higher jacket inlet temperatures obtained by radiator shutters, bypass cooling systems, or other similar devices. Temperatures in the cooling jacket should be at least 140 F, while crankcase oil temperature should be above 150 F.

Oil filters appear to be helpful if the units are serviced frequently enough, while experience indicates that frequency of oil change is a major factor in promoting engine cleanliness. General engine maintenance is an important factor in engine cleanliness.

■

Conclusion—Operating conditions, including the mechanical condition of the engine, are extremely important in engine deposition tendency, frequently producing ranges of effects larger than those produced by fuel and oil combined. Maintenance of good combustion, proper cooling jacket and lubricating oil temperatures, and satisfactory crankcase ventilation, together with the use of oil filters and avoidance of excessively long oil drain periods, will each contribute a share towards improved engine cleanliness.

BUS Air Conditioning

EXCERPTS FROM PAPER* BY

A. T. Browne

Project Engineer
ACF-Brill Motors Co.

THE vapor compression system for air conditioning buses consists of four basic elements—the compressor, condenser, expansion valve, and evaporator —and a liquid receiver for storing the refrigerant. Its successful operation depends on proper air distribution and body design as well as equipment selection.

Heart of this system is a volatile liquid, the refrigerant, which vaporizes at a low tempreature, absorbing heat if the pressure is low; it will condense at a high temperature if the pressure is high.

The simple elemental system is shown schematically in Fig. 1. Here is how it works:

1. Liquid refrigerant at high pressure is forced through the expansion valve by its pressure. The throttling effect of the expansion valve causes a drop in pressure which evaporates a portion of the refrigerant, lowering its temperature.

2. Flowing through the evaporator, the low temperature refrigerant absorbs heat from the air to be cooled, which is passing over the outside of the evaporator coil. This heat absorption causes evaporation of the liquid refrigerant to the vapor state.

3. The compressor removes the vapor from the evaporator, maintaining a low pressure in the evaporator. Application of external work in the compressor raises both the pressure and temperature of the vapor refrigerant.

4. The high-pressure refrigerant vapor, discharged from the compressor, flows into the condenser. Here heat is transferred to the cooling air passing over the condenser coils, condensing the refrigerant to a liquid.

5. The high-pressure liquid refrigerant flows into the receiver, from which it returns to the expansion valve to repeat the cycle.

The refrigerant used for all air conditioning applications on automotive vehicles is dichlorodifluoromethane, more familiarly known as Freon 12. This material has suitable thermodynamic properties, is odorless and nontoxic. Its main advantage is that there is no danger to health in case of its escape. Being odorless, it will not cause panic should it leak into the occupied space.

Equipment installed in an automotive vehicle may be divided into two groups, often designed as separate self-contained packages. These are the air conditioning or evaporator unit and the condensing unit.

The Air Conditioning Unit

The air conditioning unit conditions the air before delivery to the occupied space. Although the conditioning consists primarily of cooling and dehumidification, cleanliness and odor concentration of the air within the occupied space also must be controlled.

The conditioned air is cleaned by passing it through filters, generally of the viscous-coated im-

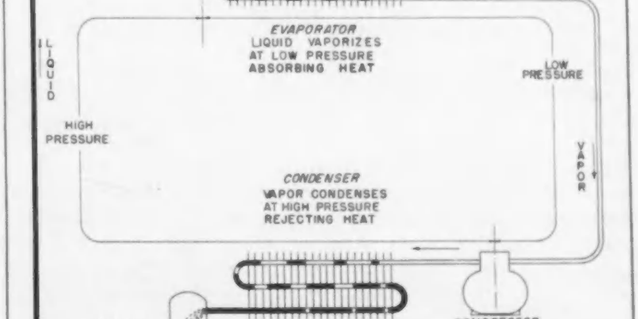


Fig. 1—Schematic diagram of basic vapor compression refrigerating system for air conditioning buses

* Paper "Air Conditioning of Automotive Vehicles," was presented at SAE Annual Meeting, Detroit, Jan. 13, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

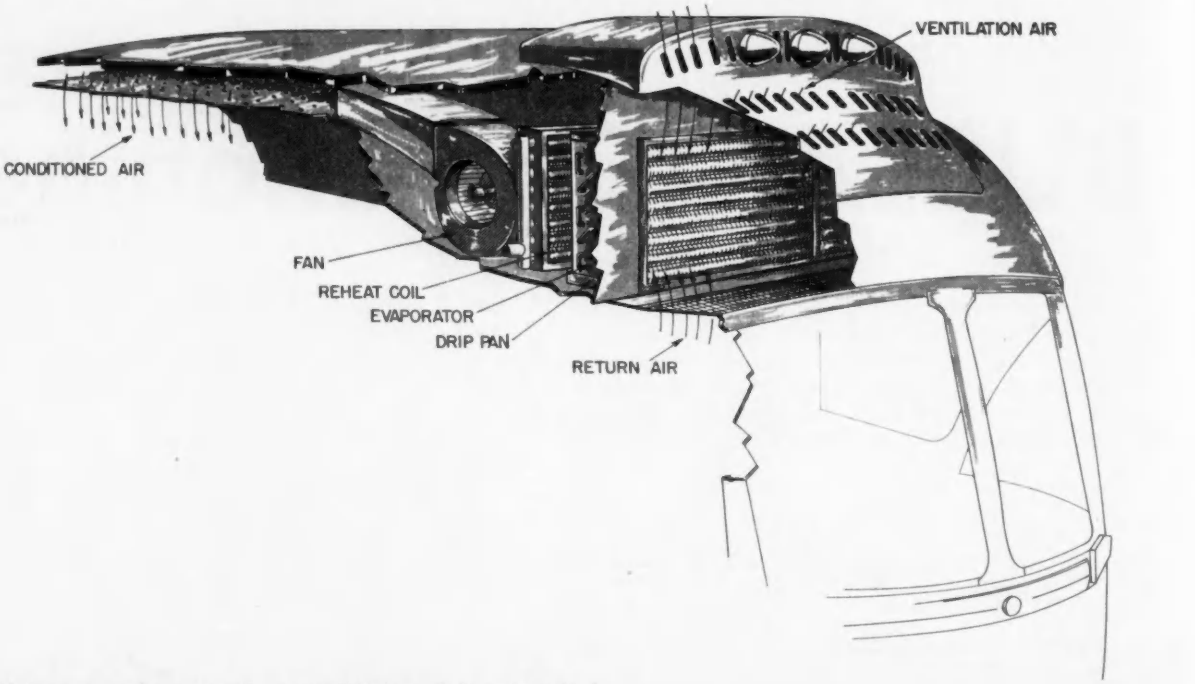


Fig. 2—This is one way of arranging the air conditioning unit in an intercity bus

pingement type. These filters remove dust, lint, and pollen from the air.

Odor concentration, mainly from body odors of the occupants, may be kept within acceptable limits by diluting the inside air with sufficient ventilation air. In general, 10 cfm per occupant of ventilation air has been found adequate, unless a large percentage of the occupants are smoking.

The air is cooled and dehumidified by the transfer of heat from the air passing over the outside of the evaporator coil to the evaporating refrigerant on the inside. This heat transfer must cool the air below its dewpoint temperature if dehumidification is to occur.

The items which comprise the air conditioning unit are the evaporator, expansion valve, reheat coil

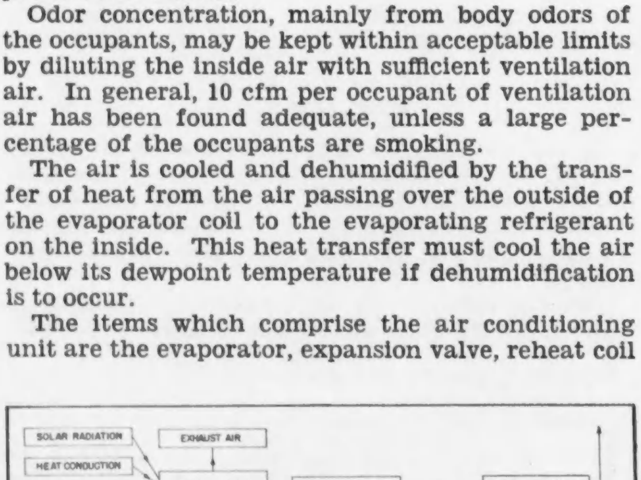


Fig. 3—Schematic of the air conditioning and refrigerating processes

(when used), air circulating fans, thermostat, and air filters. These units may be designed as a package for installing in the vehicle as a unit, or they may be installed individually. Fig. 2 is an arrangement of the air conditioning unit in an intercity bus. Although this sketch illustrates one specific design, the arrangement of the elements is basic for any automotive vehicle.

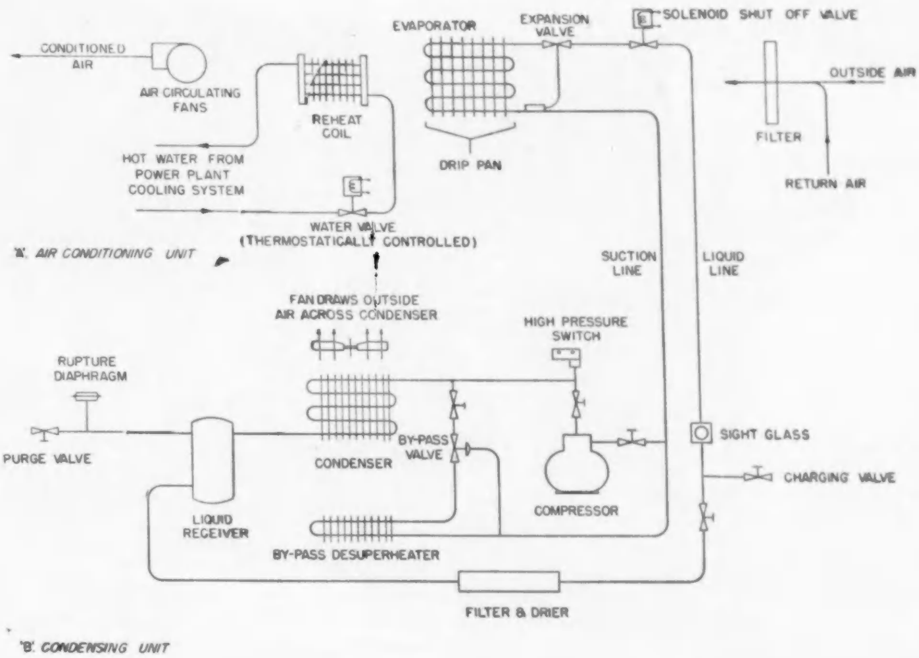
The air conditioning process is shown diagramatically in Fig. 3. Ventilation air entering from the outside meets and mixes with return air removed from the occupied space. The air mixture is filtered and then flows over the evaporator coil, where it is cooled below its dewpoint temperature by contact with the cold evaporator surface. This transfers heat to the evaporating refrigerant on the inside of the coil.

Cooling the air below its dewpoint temperature condenses a portion of its moisture on the evaporator surface, from which it drips to a pan underneath and is drained to the outside of the vehicle. The cooled and dehumidified air then flows through the reheat coil where its sensible temperature will be raised, provided it was necessary to do more sensible cooling in the evaporator than desirable to remove the required quantity of moisture. The conditioned air then flows to the fans and is discharged into suitable ducts for distribution to the occupied space.

Evaporators are the direct expansion type of copper coil construction using extended fin surface on the air side. Aluminum coils are being experimented with; but unfortunately they have a somewhat lower heat transfer efficiency. This results in a larger, though lighter, coil. For automotive vehicles the lighter weight coil is desirable; but space is too often at a premium to permit its use.

The expansion valve is the thermostatic type.

Fig. 4—Diagram of air conditioning equipment and piping



This valve both produces the necessary pressure drop at the inlet to the evaporator and meters the flow of refrigerant to keep the coil completely refrigerated at all times when in operation. This valve does not control air temperature; rather it controls the flow of refrigerant to suit the load. This valve admits to the coil just the amount of refrigerant which can be evaporated by the heat absorbed from the air. It performs this metering function by balancing the temperature of the leaving refrigerant against its pressure in such a way that a constant superheat of approximately 10 F is maintained in the leaving refrigerant.

The Condensing Unit

The elements which comprise the condencing unit are the compressor, condenser, cooling fan, liquid receiver, a means of driving the compressor and fan, and various control and safety devices. The condensing unit is shown schematically in Fig. 4.

The condensing unit receives the refrigerant vapor from the air conditioning unit, removes from it the heat which it absorbed in the evaporator, and condenses the refrigerant to a liquid.

This is accomplished as follows: Refrigerant vapor flows from the evaporator to the compressor, where its pressure is increased and consequently its saturation temperature. The pressure must be increased to the point where the corresponding saturation temperature is sufficiently above the temperature of the cooling air to cause heat to flow from the refrigerant to the air, and thus condense the refrigerant.

The refrigerant enters the condenser as a high-pressure superheated vapor, where it is condensed to a liquid, giving up its superheat and latent heat of vaporization to the cooling air flowing over the outside of the condenser coil. The liquid refrigerant leaving the condenser flows into the receiver, a storage receptacle, from which it goes to the expansion valve as required.

When cooling is not required, no evaporation of refrigerant takes place in the evaporator. If the compressor were to continue to operate, it would pump a vacuum on the evaporator. This is undesirable. In fact the evaporator pressure and resulting saturation temperature never should be permitted to fall so low that the coil surface temperature is below freezing; otherwise the condensed moisture will freeze on the coil.

There are several ways of preventing this, such as stopping the compressor, or unloading it when a predetermined minimum suction temperature is

Vehicle Air Conditioning Requirements

Air conditioning system capacity needed will vary from one to seven tons, depending on design of the vehicle and its operating conditions.

A passenger car has a heat load of about one ton. A four-ton system will satisfy conventional intercity buses carrying 37 to 40 passengers. Because of peak passenger loads during rush hours, requirements for buses in city service average from five tons on a 35-passenger bus to seven tons on a 50-passenger bus.

The vapor compression system weighs about 250 lb per ton. Its gross coefficient of performance is between 2.5 and 3 hp per ton.

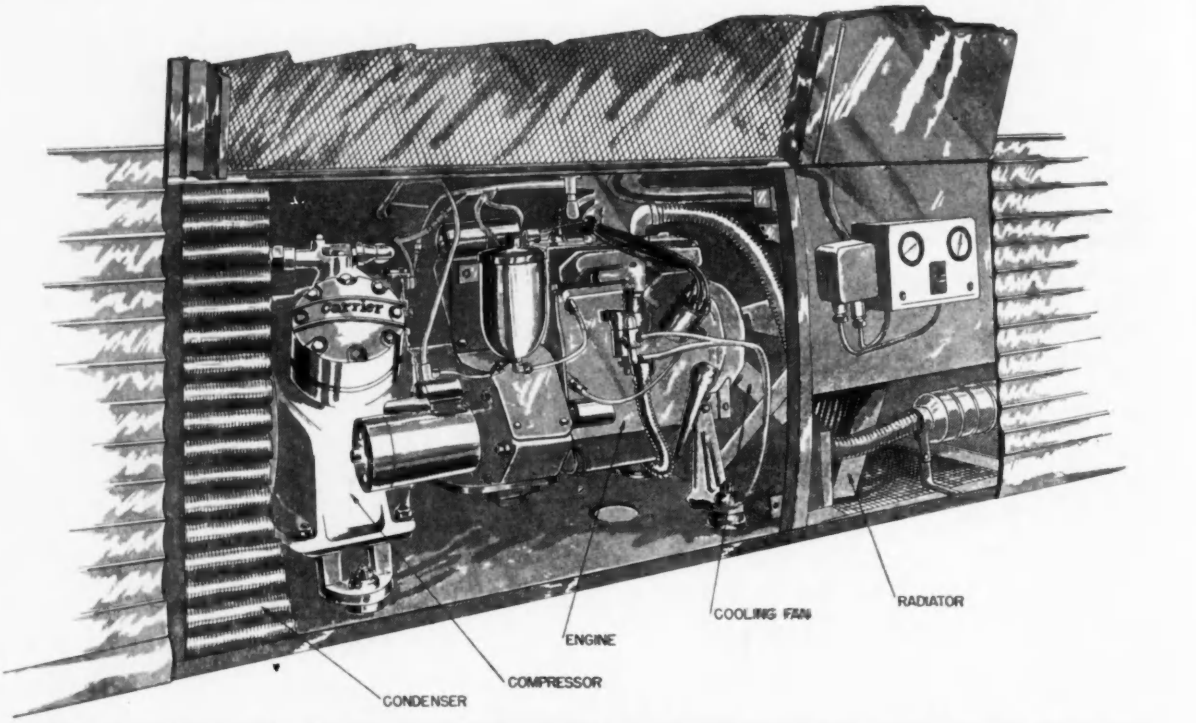


Fig. 5—A bus condensing unit with a separate gasoline engine drive, as shown here, permits the unit to operate at constant speed, or speed best suited to the load

reached. In the scheme illustrated in Fig. 4, the compressor is allowed to keep on running; but a bypass circuit around the compressor is opened at a suction pressure of approximately 40 psia by a valve sensitive to suction pressure.

Refrigerant compressors are now built following automotive practice. The old slow-speed cast-iron units have given way to high-speed reciprocating compressors capable of operating safely at speeds up to 2500 rpm. Crankcases are of aluminum alloy with replaceable steel cylinder liners. Bearings are the precision insert type of tin-base babbit or copper lead. Crankshafts and reciprocating parts are dynamically balanced. Shaft seals are of the stationary metallic bellows type having a leaded bronze nose and a nitralloy shoulder.

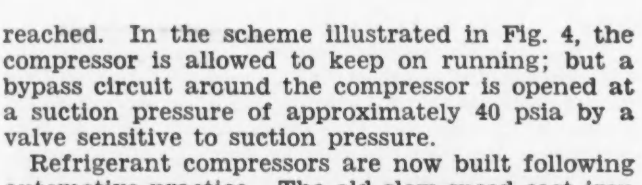


Fig. 6—Ways of distributing conditioned air in a bus. The perforated ceiling is the best

Compressors are designed with capacity control to allow the compressor displacement to be automatically varied to suit the load. This is done by a constant pressure valve sensitive to suction pressure. It acts through a mechanism to limit the suction valve when the suction pressure tends to fall below a predetermined pressure. Thus the effective displacement of the compressor is varied to that necessary to suit the load and maintain a constant low limit on the suction pressure.

Condensers for automotive vehicles are of aircooled dry type using finned copper tubing. Aluminum coils are being considered; while they represent an appreciable weight saving, unfortunately they have a lower heat transfer efficiency which means that they require more space. Evaporative condensers, using a water spray on the coil, have been experimented with, but have not found any favor. Their disadvantages are the necessity of carrying a water supply and the tendency of the wetted coil to collect dirt.

Because condensers are aircooled, they must work at a relatively low mean temperature difference if the head pressure is to be maintained within reasonable limits. This means a large surface area and generous air flow.

Fig. 5 illustrates one of two types of condensing units which have been aplied to intercity buses. It has its own gasoline engine to supply power. The

ompressor is direct-coupled to the engine and the ondenser fan is mounted on the engine crankshaft. he other type condensing unit derives its power om the propulsion powerplant by a belt drive.

Condensing Unit Drive

There are three methods in use on automotive ehicles for driving the compressor and condenser ans:

1. Direct from the propulsion powerplant.
2. A separate gasoline engine.
3. An electric motor.

In the direct drive, the compressor and condenser fans are driven by V-belts from a pulley, which may be mounted on the front end of the propulsion engine crankshaft. This drive has the advantage of making for a minimum of mechanical parts and, therefore, results in an arrangement requiring a minimum of maintenance. The disadvantage of the drive is the variable speed at which the condenser fans and compressor will operate, resulting in a variable output.

On the intercity coaches this is not a serious disadvantage for highway operation, because a high average road and engine speed is maintained. Because of the low average engine speed in city bus operation, the direct drive is not satisfactory unless a transmission is used which will convert the variable engine speed into a substantially constant output speed. In normal city operation, the engine is at an idle speed for at least 30% of the operating time.

In the private automobile, the compressor will likely be belt-driven from the propulsion engine, with the condenser located ahead of the radiator, using a common fan for cooling both the condenser and radiator.

Frequently, the compressor and condenser fans are driven by a separate gasoline engine. Generally, the compressor is directly connected through a flexible coupling and bell housing to the rear of the engine, with the condenser fan mounted directly on the crankshaft at the opposite end of the engine. The advantage of the separate engine drive is that the condensing unit may operate at a constant speed, or at a speed best suited to the load. For the usual four-ton bus system, an engine of 80 to 90 cu in. displacement and developing 18 to 20 bhp at 2000 rpm is required.

Disadvantage of the separate engine drive is the high cost involved in maintaining the small gasoline engine. This engine is operating at a constant speed and constant throttle—a severe type of operation.

An electric motor for driving the compressor and condenser fans makes an ideal drive both from the standpoint of air conditioning and the ease with which it may be controlled. The electric motor drive, however, is restricted to trackless trolley operation, since it is not practical to use the necessary horsepower electric motor on an automotive vehicle.

Air Distribution

Proper distribution of the conditioned air is most important to the success of any comfort cooling application. In public transportation vehicles the relatively low ceiling height and the high people density make the problem of obtaining uniform temperature and air motion throughout the conditioned space a most difficult one. Yet proper air distribution is essential if the comfort to be gained by cooling and dehumidification is not to be completely nullified by drafts or air stagnation.

The cooled air, being heavier than the air in the passenger compartment, will tend to fall by gravity. For this reason it is desirable that the conditioned air be introduced at the ceiling. It is also necessary that rapid diffusion and mixing of the conditioned air with that in the passenger space be accomplished if the occupants are not to be subjected to cold drafts.

Fig. 6 illustrates some methods now in use for the introduction of the conditioned air to the occupied space. Where the vehicle design permits, a perforated ceiling makes an excellent distribution system. Introduction of the cool air through many openings permits uniform distribution and good diffusion. The baggage rack duct with a perforated bottom is not quite as good because of its proximity to the heads of the passengers. Long slot outlets effect early completion of induction; but they must not be permitted to blow directly toward the occupants. Diffuser outlets are good, particularly when designed to provide internal induction.

Return air ducts are unnecessary and are seldom used. But the return air inlet to the evaporator must be located so that the entering air velocities will not be uncomfortable to the occupants in the immediate vicinity.

Separate attention should be given to the problem of driver comfort. Since he is working, his comfort conditions differ from that of the passengers. Additional spot cooling by a louvre of the Punkah type allows the driver to direct a mild blast of cool air over his body as he wishes. It is good solution to the problem of driver comfort. Commonly, the static pressure in the distribution system is inadequate for this purpose and it is necessary to augment it with a separate small fan.

Controls

Although it is desirable that the cooling system be completely automatic to relieve the driver of re-

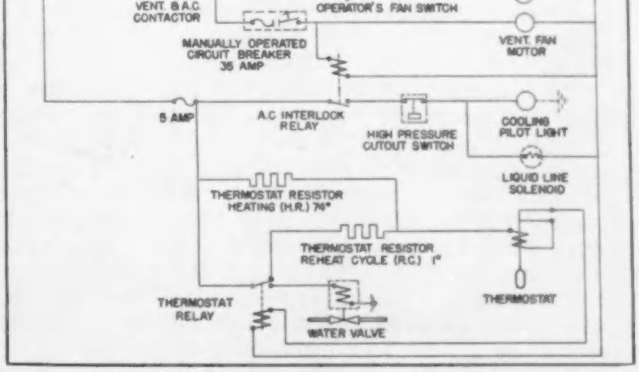


Fig. 7—Wiring diagram of a control system

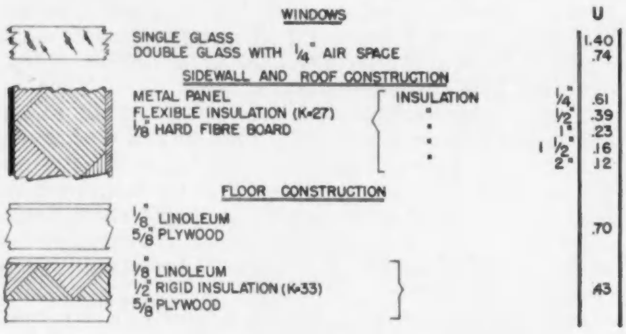


Fig. 8—Coefficients of transmission of various bus constructions

sponsibility for its proper functioning, the first emphasis should be on reliability. Frequently desired refinements must be sacrificed for dependability. The most vulnerable elements of the refrigerating system are its controls. Nothing can be more aggravating than the failure of the cooling system on the highway, later found to be due to nothing more serious than a dirty contact on an automatic switch.

No matter how simple the cause of failure, if it occurs on the highway on a hot day, it is a serious matter certainly not conductive to passenger or driver good will. It therefore behooves the designer to keep the controls as few and as reliable as is consistent with satisfactory operation.

When a reheat coil is used, comfort conditions in the occupied space are most often controlled by a thermostat sensitive to dry-bulb temperature. It limits the minimum sensible temperature by admitting hot water to the reheat coil.

A recent development is the drum switch, powered by a thermal element. It may be designed to set up any desired sequence of operations from cooling to heating depending upon the inside temperature.

To avoid freezing the condensed moisture on the evaporator coil, it is necessary to set a low limit (approximately 24 to 26 psi) to the suction pressure. One method is to stop the compressor on low suction pressure. With the separate engine drive, this may easily be done by a pressurestat in the suction line designed to open the ignition circuit on low suction pressure.

Another method is to unload the compressor instead of stopping it. A bypass circuit around the compressor is opened on low suction pressure by a valve similar in design to a constant pressure expansion valve. This is the system illustrated in Fig. 4.

The system must be protected against excessive head pressure. A pressurestat does this by opening the circuit to a solenoid valve in the liquid line when the head pressure reaches 250 psi. This causes the solenoid valve to close and shut off the flow of refrigerant to the evaporator. No further refrigerant being admitted to the evaporator, the compressor will pump down the system until the head pressure falls to 215 psi. Then the pressure will close the circuit to the solenoid valve, causing it to open and return the system to normal operation.

To avoid the danger of an explosion in the event of fire, a rupture diaphragm or fusible plug is provided at the receiver.

With the separate engine drive, certain safety devices are necessary for the protection of the engine. These safety devices include protection against low oil pressure and high coolant temperature. Safety switches designed to open the ignition circuit are used in combination with a warning pilot light to notify the driver.

Fig. 7 is a simplified wiring diagram of a typical control system.

Body Design Considerations

Success of air conditioning in an automotive vehicle depends as much upon the body design of the vehicle as upon the design of the cooling equipment. Body construction must be such that heat gain and air infiltration will be the least possible amount consistent with an economical design.

Adequate insulation of the shell is a must in any vehicle which is air conditioned. Common automotive vehicle construction consists of an outer metal skin fastened to a metal frame, and lined on the inside with metal or composition panels. Thickness of this shell varies between 1½ and 2 in. The space between should be filled with a blanket of insulation which may be cemented to the outer panels.

Fig. 8 tabulates the effect of different thicknesses of insulation on the conductivity (U in Btu/sq ft/F) of various panel constructions. Safety demands that the insulation be fireproof and, for health and cleanliness, it should be vermin proof. Preferably, the material will be inorganic rather than organic. Floors are of plywood or metal with a linoleum or rubber base covering and should have the minimum equivalent of a ⅜-in. layer of cork between.

Unfortunately, the metal framing members provide paths of heat flow between the inner and outer surfaces. Wherever possible the continuity of these paths should be interrupted. This is difficult, but a minimum of a layer of cork tape between the frame and the inside panels should be used.

Large glass area in vehicles makes the heat gain due to solar radiation an important item in the cooling load. Solar radiation passing through a window and striking directly on the body of an occupant also can be quite uncomfortable, even though the inside air temperature is within the comfort range. Window shades, used on intercity buses, are not practical on city buses or private automobiles. Where shades are used, the outside surface preferably should have a high reflectivity.

Heat-absorbing glass is extremely valuable in reducing the solar load. This glass, while transparent to light waves, is opaque to the longer wave length of heat radiation. It absorbs the heat radiation and reradiates it in both inward and outward directions. A 45% reduction in the amount of solar radiation transmitted is possible.

Some benefit in reducing the load may be obtained by a judicious choice of exterior finishes. Certainly, the roof should be finished in a light color having a high reflectivity.

On public transportation vehicles, fixed windows are desirable. But they should be capable of being opened in the event of failure of the air conditioning equipment. To prevent passengers from opening the windows, they are normally installed with locks that have to be opened with a key.

COMPRESSION

May Change Structure of Fuels

BASED ON PAPER* BY

Edmond R. Retailliau,
Harold A. Ricards, Jr.,
and Minor C. K. Jones

Esso Laboratories, Standard Oil Development Co.

(This paper will be printed in full in SAE Quarterly Transactions)

DURING the compression stroke, prior to ignition by the spark, it has been found that carbureted fuels may undergo severe prereactions, so that the fuel that is eventually ignited by the spark is no longer the original hydrocarbon material but a mixture of many hydrocarbons and oxygenated compounds.

These prereactions (which should be differentiated from the preflame reactions that take place ahead of the advancing flame front in the unburned part of the mixture after spark ignition has occurred) are initiated by compression heat. Once the reactions are started, chemical heat is usually evolved, causing further reactions to occur, probably by a chain-reaction mechanism.

Complexity of Prereactions

Even when a single hydrocarbon was used as a test fuel, cracking, dehydrogenation, polymerization, and oxygenation were observed, so that by the time the charge was ignited by the spark, it consisted of a complex mixture of oxides of carbon, aldehydes, ketones, alcohols, organic acids, oxygen-containing high molecular-weight polymers, hydrogen, methane, the lighter hydrocarbons (mostly olefins), and water, plus the part of the original hydrocarbons fed to the cylinder that did not react. Probably even more complex mixtures are formed when gasoline, which is a blend of several hydrocarbons, is fed to an engine.

Test Equipment and Procedure

All the experimental work was done on an ASTM-CFR knock-rating engine, with certain modifications. For instance, the bouncing-pin mechanism was replaced by a thermal plug, which was connected to a continuous temperature recorder. The temperature as recorded by this instrument was chosen as the criterion of prereaction, for it had been observed that the relative engine temperature, which is not the actual compression temperature, as indicated by the engine thermal plug reflected the inception and, to some extent, the degree of prereaction.

In the preliminary studies, air-fuel mixtures were motored through an unfired engine, which was driven as a compressor by an electric motor. This permitted the collection and analysis of large quantities of fuel that had been subjected to compression-stroke conditions, but without ignition and combustion.

A sensitive wattmeter was connected to the driving motor to measure changes in the power requirements during the experiments. The temperature of the cooling(or heating) medium was controlled and the liquid circulated through the cylinder jacket by means of an outside pump. The carburetor bowl was altered for accurate control

* Paper, "Precombustion Reaction in the Spark-Ignition Engine," was presented at the SAE Annual Meeting, Detroit, Jan. 10, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

of the amount of the feed. This, in turn, was used indirectly for controlling the air/fuel ratio. A shrouded intake valve was used to ensure good mixing. The spark plug was disconnected, of course, since firing was not desired in these tests.

The exhaust was condensed by passing it through a series of condensers, the last of which was maintained at -70 F, followed by a silica-gel adsorber.

After the nature and the extent of the prereactions were determined, a second series of experiments was conducted in an operating fired engine.

In this instance, the engine was connected to a d-c dynamometer for measuring power output. Speed was controlled by an electronic device. An air/fuel ratio indicator and an indicating CO_2meter were connected to the exhaust line, so that the air/fuel ratio could be adjusted.

Other control and measuring devices were the same as those in the nonfired experiments, except that the spark plug was activated by the usual CFR device. Also, the exhaust gas condensing system was not used in these tests, since combustion of the air-fuel mixture occurred.

The determination of knock intensity was both by ear (employing a trained operator) and by oscilloscope.

These experiments showed that the nature and extent of prereactions depend on both engine operating variables and on the fuel type. The tests also indicated that tetraethyl lead may suppress knock by controlling the prereactions.

Effect of Engine Operating Variables

In general, it may be said that the alteration or prereaction of fuels increases as engine operation becomes more severe.

Thus, the higher the temperatures in the cylinder at the start of the compression stroke and the higher the compression ratio of the engine, the worse the prereactions.

The temperature in the cylinder at the start of the compression stroke, in turn, is dependent upon the temperature of the following items: the intake air-fuel mixture, the jacket water, the piston top, the cylinder wall, and the residual gases present from the previous cycle, so that an increase in the temperature of any of these components can be expected to result in more prereactions taking place. In the test work it was noted particularly that the extent of the prereactions increased rapidly as the intake temperature was raised.

An increase in engine speed, on the other hand, does not allow the prereactions to be carried as far, due to the shorter reaction time available. This indicates that, within limits, a given fuel should be able to stand somewhat more severe conditions with increasing engine speed, and may partially explain why many fuels show a falling off in knock intensity as engine speed is increased.

Effect of Fuel Type

Although commercial gasolines were used in the early experiments, the work was soon simplified by the use of pure hydrocarbons, such as normally occur in gasoline blends, for gasoline is a complicated mixture of hydrocarbons, and the analysis of such mixtures is both tedious and time-consuming.

Among the hydrocarbons studied were an *n*-paraffin (*n*-heptane), a branched-chain paraffin (isooctane), and an aromatic type (benzene). The study of heptane was made by means of the only mixture used: 25% by volume of *n*-heptane and 75% by volume of isooctane.

The study of these fuels indicated that:

1. Within the range of conditions investigated, benzene and other aromatic fuels appear to resist prereaction and remain unchanged during compression prior to ignition.

2. Paraffinic hydrocarbons, on the other hand, have demonstrated a tendency to prereact. Isooctane, for instance, which is usually regarded as being extremely stable, is relatively unstable toward prereactions when it is compared with benzene, but it is more stable than its blend in *n*-heptane.

Effect of Tel in Suppressing Prereactions

To study the ability of lead to control prereactions, unfired and fired engine tests were made with tel in both the paraffinic fuel isooctane and the aromatic fuel benzene. These tests indicated that in paraffinic fuels tel has the effect of decreasing the extent of the prereactions, whereas in aromatic fuels it oxidizes without having much influence on the process. This observation is in line with the knowledge that aromatic compounds have poor tel susceptibility, and is probably due to the fact that, under the conditions of the test, there just weren't any prereactions for the tel to suppress.

So far, insufficient data have been gathered to give us a clearcut understanding of the mechanism whereby tel suppresses knock. It does seem, though, that the lead does not actually prevent the initial oxidation of the fuel, but rather that it probably destroys a large proportion of the centers of the oxidation chain; as a result, the development of the prereactions is decreased and an increase in engine severity is possible before spontaneous ignition occurs.

New Reports Added To Complete CRC List

A new and up-to-date list of Coordinating Research Council reports has just been published. Free copies of the list are available from the Society of Automotive Engineers, 29 West 39th Street, New York 18, N. Y.

Two new reports, not previously listed, are included: "Effect of Sulfur in Diesel Fuels on Engine Operation in the Laboratory," and "Recommendations for Fuel System Design for Personal Aircraft with Regard to Vapor Lock."

Features of the JETLINER

EXCERPTS FROM PAPER* BY

James C. Floyd

Chief Design Engineer—Transports
A. V. Roe Canada Ltd.

This article supplements a general description of the Jetliner on pages 17 and 18 of the December, 1949 SAE Journal.

THE Jetliner, A. V. Roe Canada's C-102 medium-range transport, is designed on reasonably conventional lines, despite its novel powerplants.

The design is now in the process of being proved by flight tests carried out from Malton, Ontario. First flight was made August 10, 1949—just two weeks after the DeHavilland Comet, the world's first true jet transport to fly, made its initial short hop.

Described below are some of the Jetliner's design features.

Fuselage

The shape of the fuselage is the usual compromise between a profile which is aerodynamically clean and a structure which is easy to assemble, coupled with the standardization of interior fittings and structure for as long a length as possible. This has resulted in a parallel fuselage section for approximately 60% of the total length with a carefully blended-in forebody and afterbody.

Special care was taken to get good lines around the nose canopy, and wind tunnel results showed that the critical Mach number around the canopy is about 0.73, that is, higher than that for the wing.

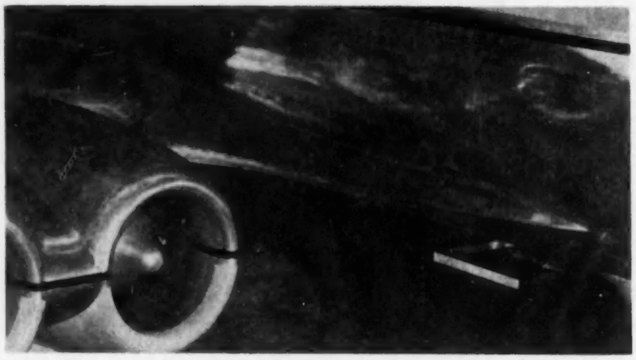
An NACA 00-21 series airfoil section has been used

* Paper "The Avro C-102 Jetliner" was presented at SAE Annual Meeting, Detroit, Jan. 9, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

for the afterbody, which showed very good pressure-recovery characteristics in the wind tunnel. A circular cross-section is used throughout, as this is obviously the best section for the high pressure differential used on this aircraft.

The shape of the dorsal fin was determined by the requirements for weather cock stability and makes available a portion of the rear fuselage as fin area.

Wings



The choice of wing section is always a compromise. The peculiar conditions which had to be met with a transport which was to be almost twice as fast as existing transports made this problem even a little more complex than usual.

It was obviously essential to cut down the drag to a minimum and at the same time to obtain the highest possible maximum lift coefficient for take-off and landing performance.

The structural problems with high gust factors and the large amount of fuel which had to be carried also influenced the wing design.

The relatively large amount of fuel carried in the jet-powered transport results in a low landing weight and, consequently, a low wing loading. These together with the increased speed make for a higher gust factor, since gust factors vary directly with the speed and inversely with the wing loading. Gust load factors are considerably higher than those used in present transport aircraft.

The highest limit load factor is 4.5 at an empty weight of 34,000 lb and a speed of 300 mph EAS. The overall wing loads were also increased due to the absence of relieving loads from conventional outboard nacelles.

To compensate for the increased structural strength required, the high-strength aluminum alloys 75ST and 24ST are used extensively to obtain the maximum strength-to-weight ratio. The outer wings are also designed as fully stressed skin structures with heavy gage skin and stringers taking the place of the usual concentrated spar booms, and providing a high degree of torsional stiffness.

The section chosen to obtain the best all-around characteristics was a relatively highly cambered airfoil, with a thickness of 16.5% at the root and 12% at the tip. The aircraft will be operating at a Mach number of less than 0.7 at 30,000 ft, and no compressibility problems are expected with this airfoil at these speeds. This airfoil also has the advantage that the trailing edge angle is low, and the pressure recovery gradient is conservative, which makes the section less sensitive to manufacturing and junction interference.

A fairly low wing loading was used for better approach characteristics. The plan shape which appeared to give the best compromise was one with an aspect ratio of 8.1 and a taper ratio of 0.5. As the basic characteristic having the greatest effect on stalling is the taper ratio, this was chosen very carefully. The straight center section makes the fuselage-to-wing junction easier to manufacture and helps in the powerplant installation as the engines are on the parallel portion.

It was considered that for an aircraft operating at a Mach number less than 0.7, sweepback would not be worth the extra weight which it would involve. The best arrangement appeared to be that having a straight rear spar, which gives a sweepback of approximately 4½ deg at the quarter chord. Washout was considered but did not seem to give any great promise as—although it gave slightly better stall characteristics—the effect of the extra induced drag at high speed was less favorable, and the manufacturing difficulties would also be very much greater.

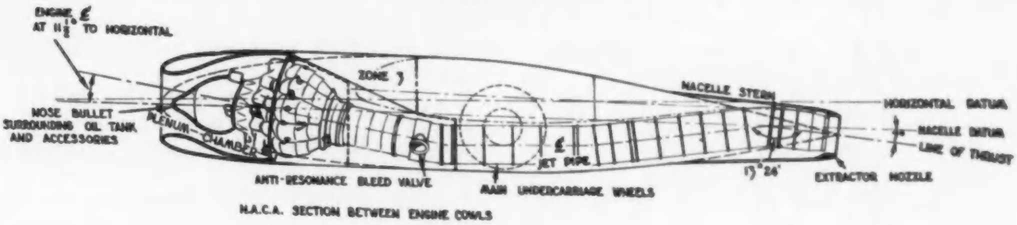
Split-type flaps are fitted on the first set of wings for the first prototype. These will later be changed to the double-slotted type to cut down the landing and approach speeds to the minimum. As these flaps are of the area-increasing type, there will be a larger center-of-pressure movement than with the split flaps, and slightly greater elevator angles to trim may be required when these are fitted.

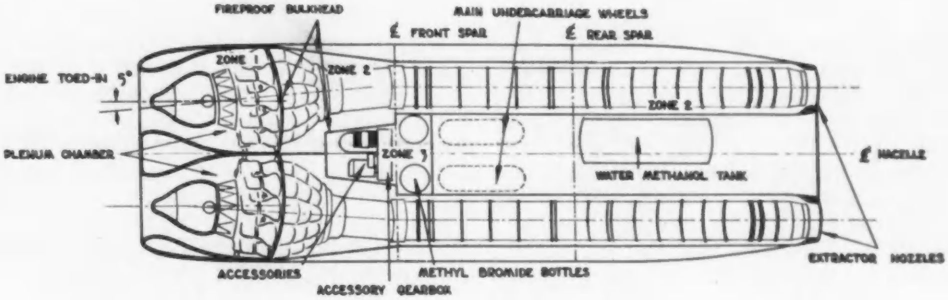
The profile drag has been kept to a minimum by the use of thick skins required for wing stiffness and complete flush riveting. Square tips are used to give greater aileron effectiveness by carrying the surfaces out as far as possible and for ease of manufacture of the tips themselves. The dihedral on the outer plane is 6 deg, and the wing incidence is 2½ deg throughout the span.

The unusual design of wing root fillet was incorporated to take care of the upwash from the fuselage. The normal component of the flow around a long-nosed fuselage produces an upflow at the wing root, which may cause premature root stalling. During wind tunnel tests, it was found that a long forward fillet of the right shape corrected this effect.

The fillet was tried out on a British aircraft by arrangement with Avro Canada and produced excellent results. The stalling speed was reduced by approximately 7 mph EAS after incorporation of the fillet. There was no effect on the longitudinal stability.

Nacelles





The four Derwent 5 engines are mounted in pairs in two underslung nacelles, each nacelle being made up as a single integrated structure. The engines are toed-in toward the center line by 5 deg, and set at approximately 11½ deg to the horizontal in order to take the jet pipes under the main spars without cutting away any of the spar structure.

The engine is supported by two mounting trunnions at approximately its center of gravity. All nacelle air loads are taken back into the mounts, which are attached to the center section front spar. The engine is steadied at the rear by a shackle plate bolted to the top of the nozzle box.

Engine servicing and maintenance is made particularly easy by the low position of the nacelles. All engine adjustments can be made without the necessity of using service ramps or ladders.

Engine removal is carried out by detaching the services and gear drive at the break points, swinging the trunnion locating caps down, and dropping the engine onto the special dolly. The engine is then wheeled away sideways to make way for the replacement engine. With this unique arrangement, an engine change can be made very quickly.

The jet pipes are parallel in plan and are supported on trunnions and links. Two spherical joints are incorporated to give flexibility to the pipes on expansion, and also for the withdrawal of the jet pipe for engine removal. Although a relatively long jet pipe is used, it is estimated that less than 1% of thrust is sacrificed from the combined effects of length and shape of the pipe.

A 16-in. nozzle is fitted, and the jet emerges at 7 deg to the datum line of the aircraft, to bring the line of action of thrust as close to the center of gravity as possible.

The jet pipe runs through a tunnel of stainless steel formed by firewalls attached to the adjacent structure. The jet pipe itself is insulated and is cooled by a flow of air passing through the firewall tunnel and induced by the extractor nozzle. The vena contractor at the nozzle sucks the cooling air through the nacelle after it enters through louvers at the forward end of the cowling.

The external and internal shape of the nacelles was chosen very carefully with a view to getting the best possible pressure recovery characteristics externally and an efficient plenum intake which would give the best compromise between the ideal low- and high-speed conditions.

For take-off conditions where there is very little ram effect, there is a suction in the plenum chamber. In order to prevent break-away around the intake walls, the wall angle was kept down to less than 10 deg. To achieve this, it was necessary to go to separate intakes for each engine. (With a common elliptical intake, the diffusion angle would have been excessive in a short nacelle. Any increase in nacelle length was disadvantageous due to the destabilizing effects of a long, wide nacelle.)

The best intake curves were established in conjunction with the engine manufacturer's recommendations. For the outside shape, the lines between the inside lip of the intake radius and a point about 20% of the total nacelle length aft of the intakes were most critical both for drag rise and intake efficiency. The jet nozzles are inclined at an angle of 7 deg to bring the line of action of the jets as close to the normal center-of-gravity position as possible and minimize the effect of change of trim between power-on and power-off.

The jet stream has a cleaning-up effect around the trailing edge of the wing center section. When the engines are opened up during a balked landing,

air is drawn into the jet stream over the adjacent wing surfaces due to the greatly increased velocity through the jet nozzles. This has the effect of reducing the stalling speed under these conditions.

With the engines installed, the nacelle is divided into two compartments on each side and a third compartment housing the accessory gearbox. This division is achieved by means of special firewalls and bulkheads. Each nacelle has a vertical firewall forming a center keel and isolating the two engines from each other.

The engine has an integral intermediate firewall permanently attached and situated around the combustion chambers. This mates with a permanent portion of firewall on the nacelle, forming a complete firewall between the hot and cool portions of the engine.

The front portion, or Zone 1, which also forms the plenum chamber contains the engine accessories and oil tank, while the rear portion or Zone 2, contains all the hot portions of the engine, combustion chambers, turbine casing, and jet pipe. The intermediate firewall is to prevent high-pressure fuel from a burst pipe or joint being sprayed into the hot side. The rear portion of Zone 2 extends in the shape of a tunnel back to the jet nozzle and is completely lined with stainless steel firewalling and sealed against ingress of fuel or oil.

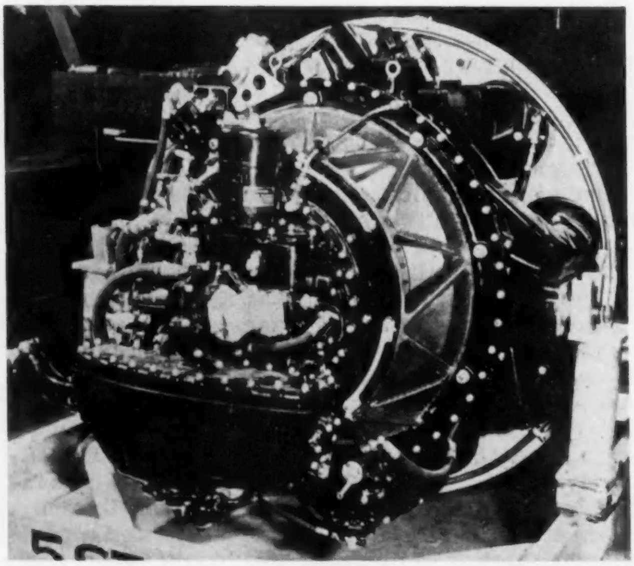
Fire from a burst combustion chamber or perforated jet pipe would be confined within this zone out of reach of electrical and fuel lines or the aircraft structure.

This system of firewalling also isolates all engine parts from the accessories and gearbox, which are in the space above the conical firewalls shown as Zone 3.

Edison resetting-type fire detectors are used. A methyl bromine system of extinguishing is used for Zones 1 and 2. A CO_2 system is provided for the gearbox compartment, Zone 3. A two-shot system is used and the warning lights, buttons, and selector switches are mounted on the ceiling fire-protection panel in the cockpit.

The upper part of the cowling is developed as a permanent structure provided with small access doors for engine slinging and a larger door to permit access to the upper part of the accessory gearbox. The lower half of the cowling consists of two large access doors hinged at the sides and a smaller door beneath the accessory gearbox swinging aft. All access doors are locked by means of flush-type quick-release fasteners. The two main curved doors can be quickly detached by swinging them out and unhooking the special hinge locators.

Engines



The C-102 engines are Rolls-Royce Derwent 5 engines with a completely redesigned oil tank. The cast oil tank is located at the front of the engine, underneath the forward gear drive. The change from starboard to port engines is made simply by interchanging the filler neck and blanking plate on the oil tank and swinging the gear take-off around in the opposite direction. The oil tank and system are integral parts of the engine.

Relighting in the air is possible. Numerous relights have been carried out during flight tests.

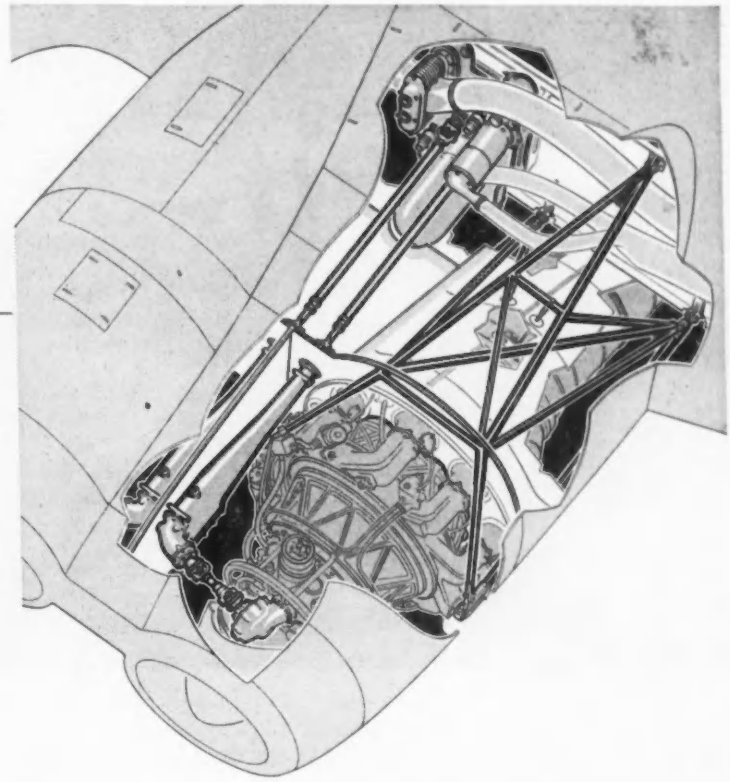
The economy of the C-102 has been worked out assuming that all engines are operating, and relighting would not normally be employed. Each engine consumes less than 90 lb of fuel in descent from 30,000 ft at half maximum cruise rpm. If the operator felt, however, that stacking should be carried out at fairly low altitude, two engines could be closed down to conserve fuel.

The thrust from a jet engine varies considerably with temperature and airport altitude. On a hot day with a temperature of 110 F, the reduction in jet thrust can be as much as 16%. As this can be critical for take-off conditions, where a possible engine failure has to be taken into account, some means of thrust augmentation has to be used.

Various means of achieving the extra thrust were investigated, and it was finally decided that injection of a water-methanol mixture into the compressor inlet offered the best solution. The predominant effect of this is to increase the mass flow of air to the engine by increasing the air density at the compressor inlet.

The injection system itself is relatively simple and has few of the disadvantages of other forms of augmentation such as afterburning, where the long sheets of flame coming out of the tailcone are likely to cause alarm to the passengers.

Engine Accessories



The main accessories driven by the engines are mounted on an accessory gearbox located between the engines in each nacelle and attached to the wing front spar. The gearbox contains two completely independent gearing systems, each driven by one engine and each having independent lubrication.

Each inboard engine drives a cabin blower, a vacuum pump, and a tachometer generator. Each outboard engine drives a 50-kw alternator, a 9-kw generator, a hydraulic pump, and a tachometer generator. The gearbox drives are connected with the engines by a system of drive shafts linked by means of flexible couplings.

Cockpit

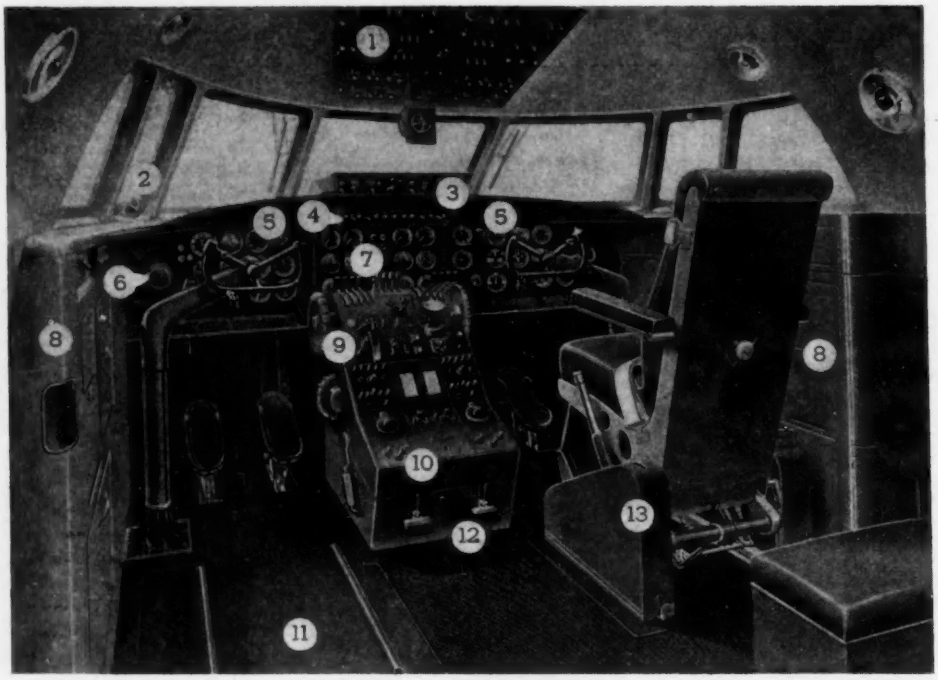
The main instrument panel is divided into three sections. The center panel carries all engine and fuel instruments. A small fuel system control panel is attached to the engine panel with the fuel diagram etched on. This contains the switches and lights for the various booster pumps and cross-feed warning lights. All panels are hinged for easy access.

The engine instrument panel is very much simplified by the use of jet engines, as the only engine instruments are the rpm indicators, jet pipe temperature gages, burner pressure gages, and oil pressure warning lights. The two main instrument panels carry the normal flight instruments, which have been grouped to conform with the latest requirements for radio navigation and automatic landing aids.

In the ceiling, between the pilots and within easy reach of each is the main electrical panel carrying the engine starter switches, fire protection switches and buttons, and the main electrical control switches. The pressurization control panel is on the left of the captain. The air conditioning, oxygen, and de-icing control panels are to the right of the first officer. Circuit breaker panels for both electrical and radio equipment are mounted on the aft flight deck bulkhead.

Both pilots' seats are fully adjustable and slide back for easy access. Cranked control columns are used to avoid obstruction to the pilots' knees. A spectacle type of aileron hand wheel is used.

A lot of thought was put into the main control pedestal, which on the upper portion carries the engine throttles, undercarriage, flap, and automatic pilot controls, the emergency manual low-pressure fuelcock levers, and fuel tank selectors. The radio



1. Ceiling switch panel, 2. direct vision window, 3. radio compasses control panel, 4. fuel system panel, 5. flying instruments panel, 6. nose wheel steering hand-wheel, 7. engine instruments panel, 8. ancillary control panels, 9. auto-pilot panel, 10. radio controls, 11. captain's seat, 12. gust lock and parking brake, and 13. first officer's seat

control panels are situated on the lower portion of the pedestal. The pedestal also carries all the manual trimmer controls, the manual autopilot disconnect lever, gust lock and parking brake levers, and the aileron power boost cut-out.

Direct vision windows which swing inward are provided for landing under adverse weather conditions. The rudder pedals are fully adjustable and are articulated to provide toe brakes for equal or differential brake application.

This cockpit layout was finalized only after many conferences with airline pilots and technicians. The final mock-up was carefully checked to get the best possible layout.

Flying Controls

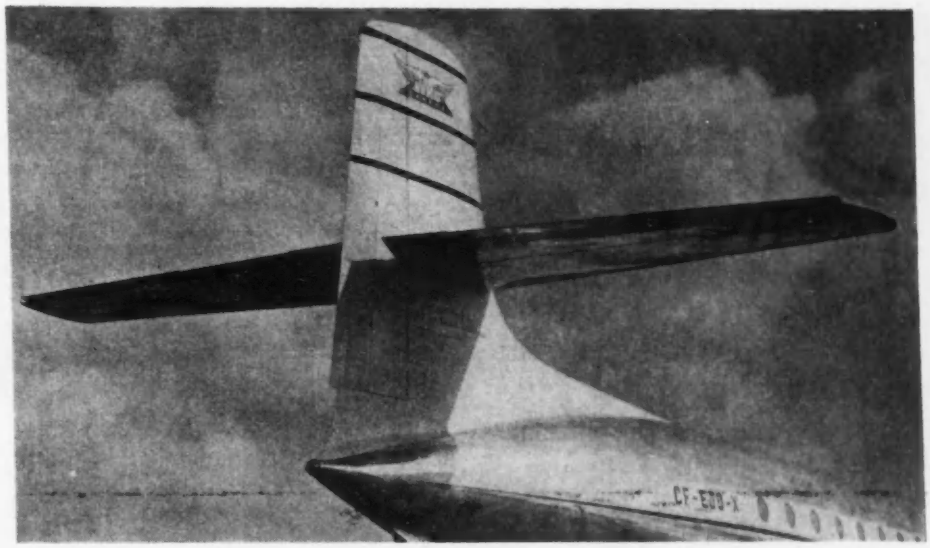
Double aerodynamically unbalanced control surfaces have been used for both the rudder and elevator controls. The intermediate or auxiliary surface on the rudders is used solely to trim out for an engine failure at low speeds. With the use of jet engines, high rudder angles are not normally necessary due to the absence of slip stream, which is the usual cause of swing at take-off. The engines are also close to the fuselage, which again reduces the rudder power required.

The tailplane is located high on the fin. If the tailplane were on the center line of the fuselage, it would be directly in the wake of the jets. While the temperature effects of the jet stream are not too serious by the time they get back to the tail, the velocity effects are more marked. If the tail were just out of the jet stream, but fairly low down on the fin just above the fuselage, there would be a marked interference between the sharply tapered afterbody and the tailplane.

The tailplane is out of the flap wake during landing. Therefore, the tail efficiency is high, which reduces the elevator angles required for normal trim. The auxiliary surface is required only for the flare-out on landing with an extremely forward center of gravity. Piano hinges have been used on all tail surfaces. This improves the effectiveness by sealing the gaps.

Narrow-chord, high-aspect-ratio surfaces are used. These have the advantage that no aerodynamic balance is necessary. They also have lower drag, less danger of icing, better repeatability, and low weight of mass balance. The narrow-chord elevator is also very much better from the point of view of susceptability to oscillatory instability. The usual cures for this are less aerodynamic balance and a lower mass moment of inertia. These features are all incorporated in the double-surface control.

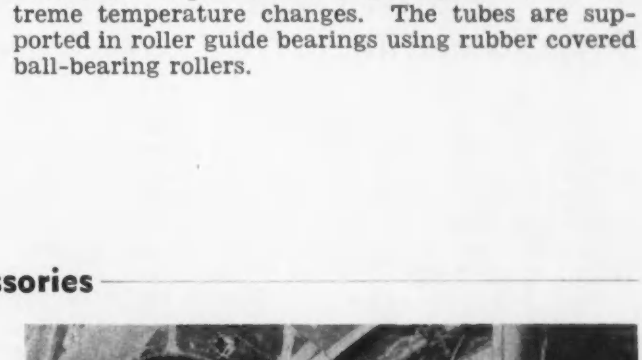
Power operation of the tail surfaces on the first prototype is by a simple switch controlling a small electric motor and limit switches. The system is entirely separate from the electric and manual elevator trim. A hydraulic assister is used for aileron power boost in the ratio of 5 to 1. This is a pure



assist system, and in the event of a hydraulic or unit failure, the booster is thrown out and full manual control is retained with, of course, reduced power.

Push-pull type controls are used on all three main control systems. Use of light alloy tube eliminates differential expansion and contraction under extreme temperature changes. The tubes are supported in roller guide bearings using rubber covered ball-bearing rollers.

Accessories



An accessories compartment was introduced behind the first officer's bulkhead on the starboard side to carry the main aircraft accessories. The heater, refrigerating turbine, main electrical accessories such as inverters and relays, and the main electrical distribution panel are all housed in this compartment, which has its own fire extinguishing system.

All radio and electronic units are in a similar separate compartment on the port side behind the pilot's hulkhead. (See illustration.) The main hydraulic units are panelized, the panels being housed in the forward wing root fillet, with easy access at ground height to all ground connections, accumulator, and valves. The emergency power pack is also contained on these panels.

Methyl-bromide engine fire protection bottles are housed in the nacelles at shoulder height, and the engine starter relay panels are also in this vicinity. The extremely low static position of the aircraft insures that practically all external servicing is done without steps or servicing ramps. Ground pressure tests can also be carried out by connecting up the ground pressurizing equipment to a service panel inside the nose wheel well.

What's Wrong with Billy's Dream

1. It Violates Legal Requirements.

Unfortunately for Billy, legal restrictions must be applied to mass-produced automobiles, notes JOHN NAJJAR, Ford Motor Co. The dream car doesn't meet them.

For example, minimum average headlamp height above the ground is 30 in. Using this headlamp as the beginning of the pontoon practically dictates height of the fender line.

Road lamp minimum height is 24 in. from the ground, and when they are built in, they pose a definite problem. The parking light cannot be closer than 7 in. to the headlamp, center to center, when used as a front turn indicator. The tail light, also restricted as to position, cannot be lower than 24 in. and higher than 42 in. from the ground.

These and other legal dimensional limitations as well as predetermined company specifications influence design and styling.

From the company's standpoint, package size is important as regards both price and utility. Road conditions, garage widths, and turning radii all have a bearing on the car's overhang, ground clearance, and overall width.

In the sketch below we have superimposed Billy's car on our "restriction" car. Billy's car is in solid outline, our highway commissioner and company-approved car in dotted lines. Note that the approved car is higher, has greater ground clearance, and reduced overhang.

2. It's Far From Comfortable.

The transparent plastic top may look good on Billy's low-slung model but it sure isn't comfortable on a sunny day, observes HIRAM PACIFIC, Ford Motor Co.

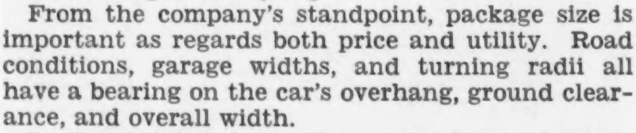
Comfort consideration is a must in every body design, he continues. We must be able to drive a car for long periods without becoming fatigued. Eyes must not be strained, backs not bent, muscles not cramped, and nerves not strained.

Seating heads the list of comfort items because it's an insulator against fatigue. The seat must counteract unpleasant vibrations. Its design should reflect considerations such as eye level, leg support, and body posture.

Insulation, another body design tool for passenger comfort, should be put to work to deaden sounds, absorb noises and vibrations, and keep out heat and cold.

Visibility also contributes to driving comfort. Designers must aim for maximum amount of windshield, side, and back windows with a minimum loss of body strength. Moving the corner post rearward aids forward visibility. Reducing the rear quarter roof panel blind spot by increasing the back window area increases rear vision. In some cases, curved glass distorts vision.

Other visibility considerations are windshield wiper design, somewhat complicated by adoption of curved glass; defrosters to prevent steamed interior windows; and windshield washers.



* From panel discussion "A Functional Approach to Body Design," presented at SAE Annual Meeting, Detroit, Jan. 12, 1950. (This panel discussion is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Car?

Billy's dream car, above, like most slick car body designs served up by Sunday supplement artists, suffers one big fault—it isn't practical to produce. Dreams are not the stuff functional, mass-produced cars are made of, Najjar, Anderson, Pacific, and Gaulien show in this article.*

They point out four musts for acceptability, none of which is fully met by stylist Billy's design. These requirements are: (1) acceptable under legal restrictions, (2) conducive to motoring comfort, (3) structurally rigid, and (4) roominess without excessive width.

3. It's Structurally Unsound.

Absence of pillars in Billy's dream car indicates lack of due consideration to structural factors to LEE ANDERSON, Chrysler Corp.

Anderson sees a growing urgency for a structure-consciousness in body styling because 75% of the conventional car's rigidity comes from the body itself.

The body engineer can impart the needed rigidity in several ways. First, frame and body attachments demand special attention because much overall rigidity is gained or lost at these points. Forces are transmitted from the frame through these mountings, letting the body function efficiently in resisting torsional and beam loads.

Because many of the major car structural members which contribute to rigidity are concealed by the body shell, they are often overlooked by stylists. One main member is the sill box section, along each side, which extends almost from the front of the body to the rear wheel house. To this main base are attached the three main pillars. The roof rail completes the framing of the door openings.

The cowl section has several important structural members, including the dash-to-frame braces, the cowl bar, and often the instrument panel. Across the top of the windshield is another important member, the windshield header, which is joined at its ends by the windshield pillars and the roof rails. Back of the passenger compartment is the package shelf, cross bracing or gussets, and rear window framing. At the rear is the cross sill and framing of the trunk opening.

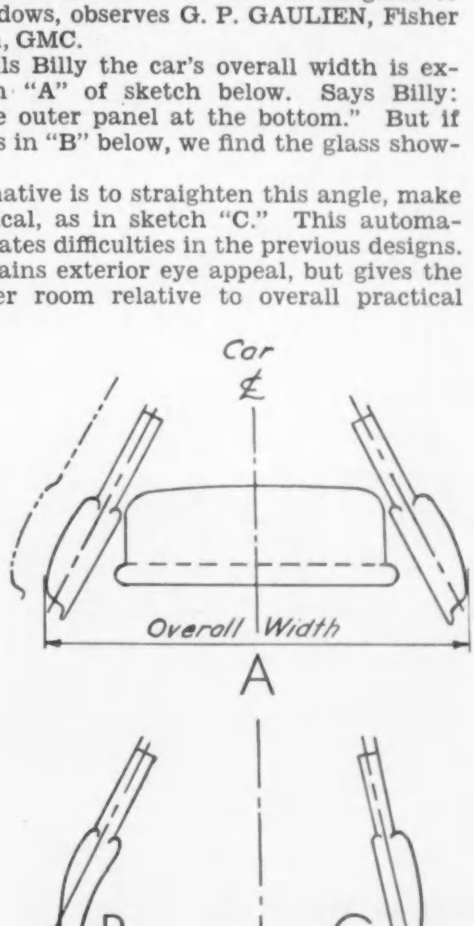
Through analysis and laboratory and road tests the body engineer can tell whether his design is strong and rigid enough. One sign of structural rigidity is that mellow, solid sound—without obvious movement of lock pillar—when the doors are closed.

4. It Wastes Inside Room.

Rakish angle of the side windows on Billy's car cuts shoulder room and calls for curved glass to close the windows, observes G. P. GAULIEN, Fisher Body Division, GMC.

Gaulien tells Billy the car's overall width is excessive, as in "A" of sketch below. Says Billy: "Bring in the outer panel at the bottom." But if we do that, as in "B" below, we find the glass showing.

Only alternative is to straighten this angle, make it more vertical, as in sketch "C." This automatically eliminates difficulties in the previous designs. It still maintains exterior eye appeal, but gives the most shoulder room relative to overall practical width.



Why Engine Bearings

BASED ON PAPER* BY

W. E. Thill

Federal-Mogul Corp.

1. Improper

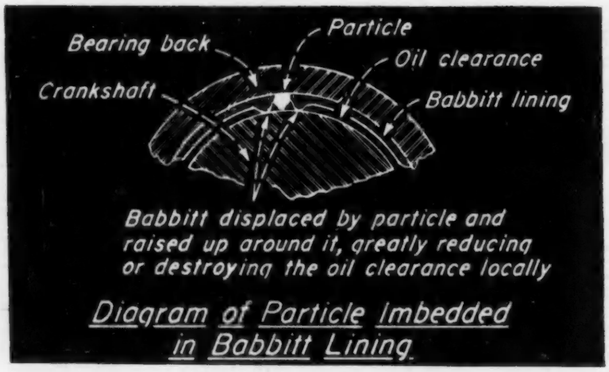
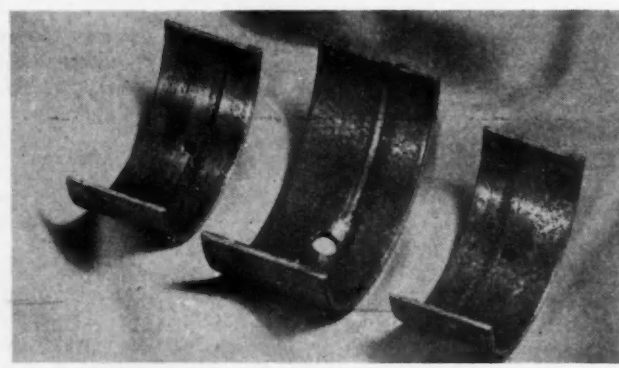
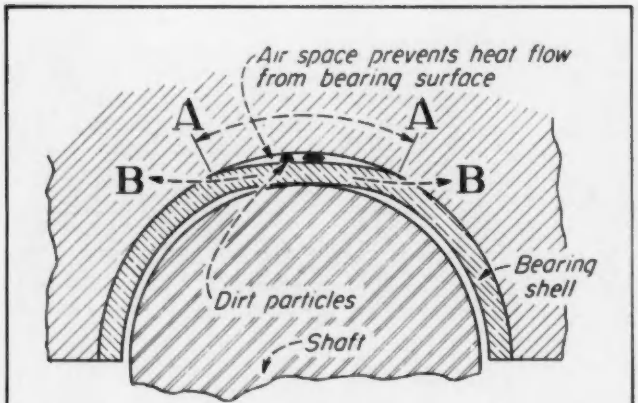
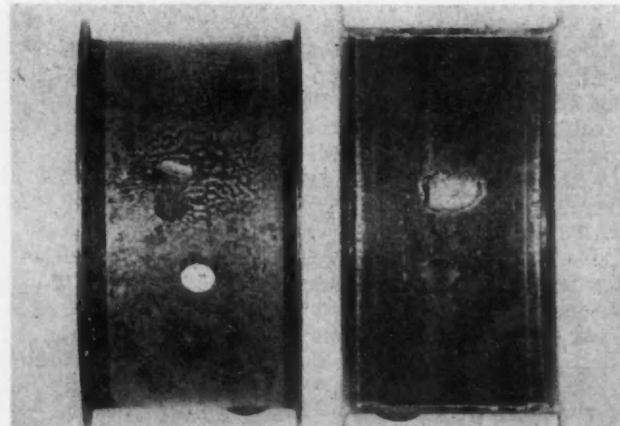


Diagram of Particle Imbedded in Babbitt Lining



Dirt in bearing lining embeds itself, as in the sketch above. Each particle displaces the lining material. The material has no place to go, except to form a crater around each particle. Some dirt is expected; but it becomes serious if the mechanic is careless cleaning up after any metal-removing operation, such as crankshaft regrinding or cylinder reboring. The bearings at right suffered this condition. Bearing walls thickened because of cast-iron particles.

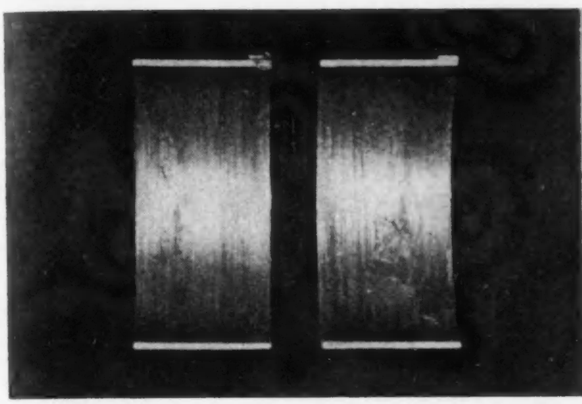


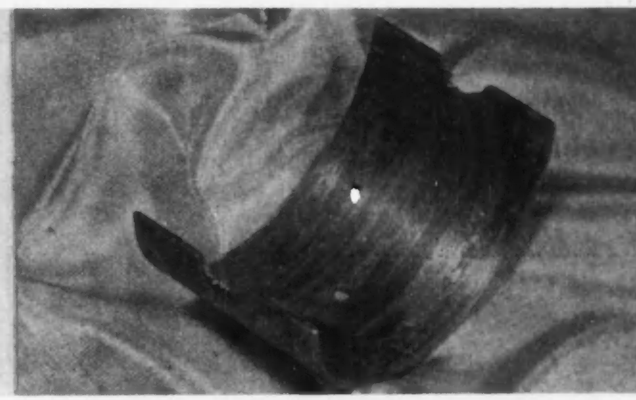


Dirt in bearing seat deforms the bearing and causes a high spot, as diagrammed above. Result: early failure due to load concentration and local fatigue. Leaving a large steel particle in the housing did the damage shown at right. Both sides of the same bearing are shown.

Fail: 1. Improper Installation 2. Poor Operation 3. Faulty Manufacture

Installation



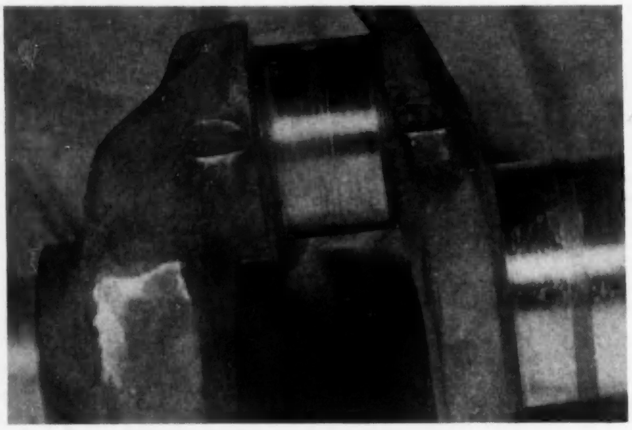


Guessing shaft undersize is another sure way to induce premature bearing failure. The pair of Dodge connecting rod bearings at left became wiped due to insufficient oil clearance. The mechanic "imagined" the wear to be 0.002 in. Failure of one rod bearing caught him by surprise. He thought the bearing was at fault. The copper alloy bearing failure at right is the product of another "guestimate." The mechanic thought the crankpins were 0.010 in. undersize; this one was only 0.008 in undersize. There is no substitute for actual measurement.

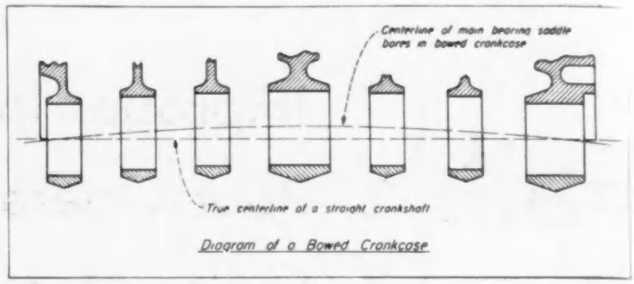
Not using a torque wrench causes too little or too much tightening. That's what made the rod bore oval and caused this failure.

Wrench interference causes "cap shift." Pulling the wrench handle forces the cap into an unnatural and shifted position. Bearing offset makes the bearing corner scrape oil off the shaft surface.

* Paper "Engine Bearings, Construction and Performance," was presented at SAE Metropolitan Section, New York, Dec. 7, 1949. (This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

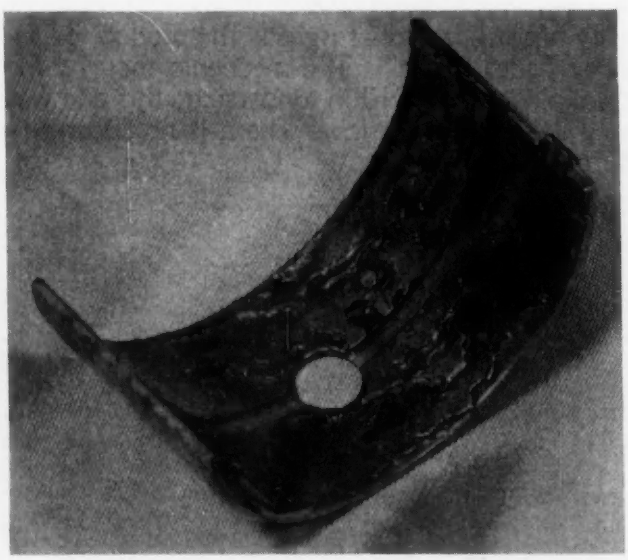


Poor crankpin and journal surfaces, like these, can lead only to poor bearing performance and shortened life. Crankpins should be round and not scored.

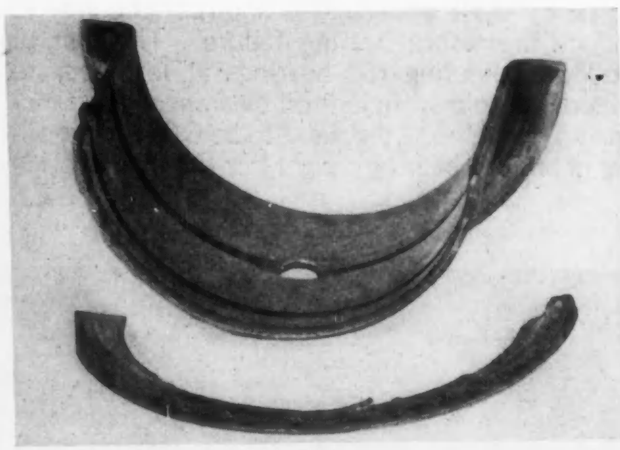


Crankcase distortion, exaggerated here, is not necessarily due to faulty design. Often continuous annealing due to constant temperature change does this. Only effective cure is to bore undersized bearings to regain straight and true alignment.

2. Poor Operation

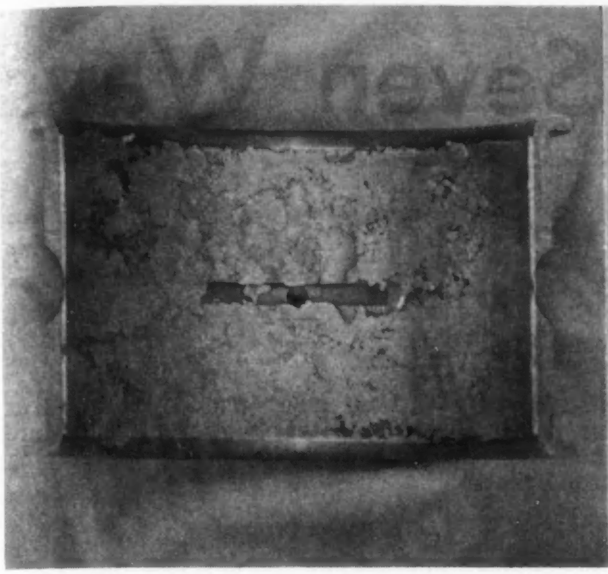


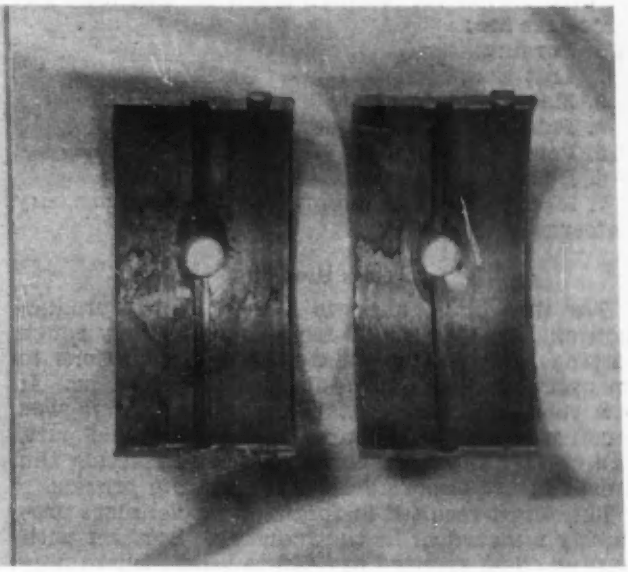
Overspeeding the vehicle causes premature fatigue failures. Most drivers claim it's impossible to overspeed governed jobs. They forget to consider downhill travel allowing the truck to roll with the engine engaged in high gear, or too fast a road speed in a lower gear. The tin-base babbitt bearing above failed in fatigue.



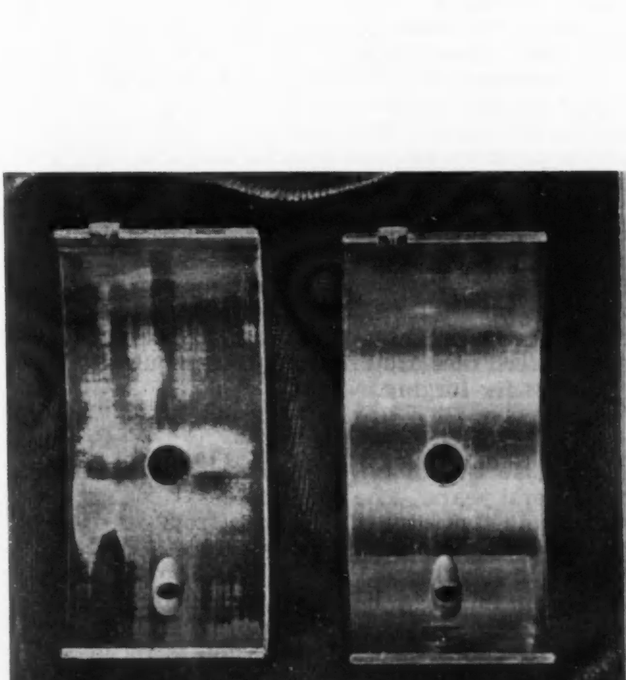
Too much clutching also can cause distress in bearings. Drivers often unconsciously use the clutch pedal as a foot rest. On some vehicles, keeping the foot on the clutch pedal—however lightly—puts a direct thrust on the engine crankshaft. The constant pressure seals off oil flow between bearing flange and crankshaft thrust disc. This lack of lubrication produces high wear or total failure of the main thrust bearing flange.

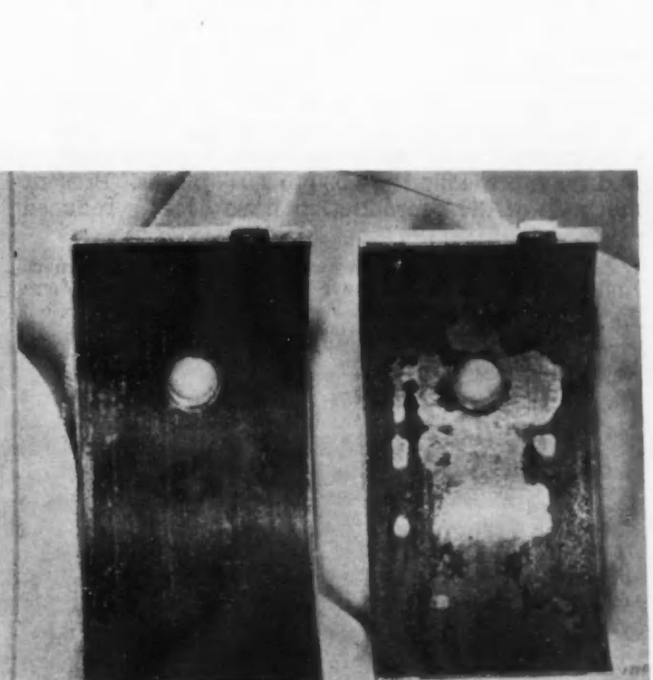
3. Faulty Manufacture





Poor bond of lining to backing is easy to differentiate from other failures. The bearing at left failed from causes other than bond. Inspecting the bottom of the voids with a pocket knife readily shows soft tinning still adhering to the steel. Presence of tin definitely indicates the bond was originally sound. The bearings at right did not have the chemical adhesion of lining to back. Bare steel is exposed in the bottom of the voids. These were poorly bonded.





Bearing surface corrosion is a rare malady of cadmium and copper alloy bearings. Acid deteriorates the lining surface, destroying the alloy and its ability to function as a bearing. It happens when the oil becomes contaminated and forms complex organic acids. They select cadmium, in cadmium alloy bearings, or lead in copper alloy bearings to form another chemical compound. Darkened area of the cadmium alloy bearing at left was attacked in this way and the copper alloy bearing at right suffered the same kind of surface disintegration.

Seven Ways ... TURBINE

GAS turbine blades and vanes currently are being made by seven different processes, each of which is best suited for certain types of blading. The processes are:

1. Forging,
2. Lost wax,
3. Machining,
4. Fabrication (sheet-stock forming),
5. Powder metallurgy,
6. Rolling, and
7. Mercast (precision casting with frozen mercury patterns).

Forgings Used First

The first blades used in United States' production engines were made from comparatively rough forgings, finished by hand-polishing operations to an approximation of the desired airfoil shape. It was soon apparent that the original forging was much more uniform than the hand-polished part, and greater effort was directed toward meeting the finished-part dimensions by the forging process.

This effort resulted in forgings to tolerances previously unheard of in the industry. Sections with trailing edges reduced to 0.008 to 0.012—where previously 0.030 to 0.040 was considered practical—are now in regular production. Airfoil contours are being held to within ± 0.003 of the mean.

Paralleling this work, improvements in forging technique, die design and die manufacture have reduced costs to a practical figure. The greatest proportion of blades and vanes used to date has been made by this process. For blade producibility in time of war it offers a good background of experience, good reproducibility, low cost, and reasonably fast production.

The forging process does use heavy equipment and somewhat large quantities of dies. Die life for compressor blades averages 10,000 to 15,000 pieces and for tubrine blades, 1,500 to 2,000 pieces. Present methods of die reproduction have greatly reduced the amount of skilled help formerly required at this point. Press operators, however, do require a high degree of skill. Fig. 1 shows stages in forging turbine blades.

* Paper "Blade Design and Production," part of panel discussion on "Optimum Engine Producibility," was presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 7, 1949. (Complete panel, of which this paper is a part, is available in multilithographed form from SAE Special Publications Department. Price: 75¢ to members, $1.50 to nonmembers.)

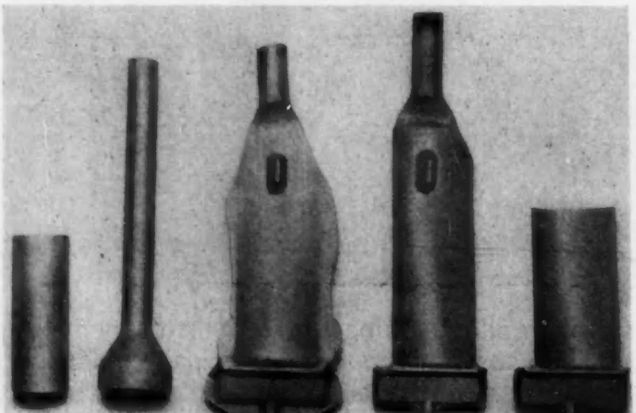


Fig. 1—Stages in forging turbine blades

Lost Wax Process

Compressor and turbine blades and vanes are made by the well-known "lost-wax" investment casting process, and this industry has contributed greatly to the jet program. Using alloys which could not practically be machined or forged, large quantities of turbine blades and vanes have been made from high-temperature materials, particularly Vitallium. The process is best adapted to small parts, both from the standpoint of mold cost and tolerance; but large turbine blades and nozzle vanes have been made in quantity.

Reproducibility is excellent for small parts and acceptable on turbine engine blades and vanes. The method is best suited to solid parts, although many hollow parts with simple interior surfaces have been made.

Lost-wax casting is more expensive than forging and does not allow the precise grain size and dimensional control possible with well-made forgings. The process is important in making parts of nonforgeable materials, and is useful for small quantities of experimental parts due to the fact that wax-pattern dies are ordinarily more quickly made than dies for forging.

Machining Blades

Machined blades have been widely used in the past several years. The usual process depends upon duplicating the form of a master from an oversize forging, using one of the common methods of machining or grinding.

Contrary to most other processes, the root or fastening device is usually the first machining operation on the forging, and the airfoil is formed, locating from the root. There are obvious advantages in control of airfoil lean, fore, and aft as well as radial, in relation to the root. This process has good reproducibility with simplified inspection procedure. Warpage and deflection during machining can occur, so this process also presents problems unless tolerances are adequate. Machined blades are ordinarily polished to a smooth finish.

Costs of these parts are usually greater than those made by other processes. Since there is a very

to Produce

BLADES

EXCERPTS FROM PAPER* BY

A. T. Colwell

Vice President

K. M. Bartlett

Director of Research

and R. E. Cummings

Manager, Engineering and Sales, Jet Division
THOMPSON PRODUCTS, INC.

strong trend toward lower costs in the gas turbine industry, this process may not be universally adopted. For high production, a large quantity of machine tools would be necessary.

Fabrication

We consider as fabricated blades and vanes those made by forming of sheet stock, with or without welding, to complete the operation. The Germans made wide use of such parts to achieve economy of critical material, lightness, and, in some instances, air cooling.

Large numbers of nozzle vanes have been made in the past by this process, such as that shown in Fig. 2. Materials fabricated by this process were of the low-alloy group, and as operating tempeartures increased, some fabricated parts were replaced by castings of high-temperature alloys. Renewed interest in low cost, light weight, and air cooling, together with the development of high-temperature alloys in sheet form, promises to revive the use of this type of part.

In this process, the designer can do much to assist the manufacturer, since it is obvious that low-twist, uniform-section parts can be made very readily. However, it is possible to produce blades having twist and a varying airfoil section and wall thickness, if such a design is necessary. But here again the simpler design will be the cheaper and performance tests must dictate the design.

Development of fabricated blades for the compressor and turbine may have a very beneficial effect on an emergency production program for the following reasons:

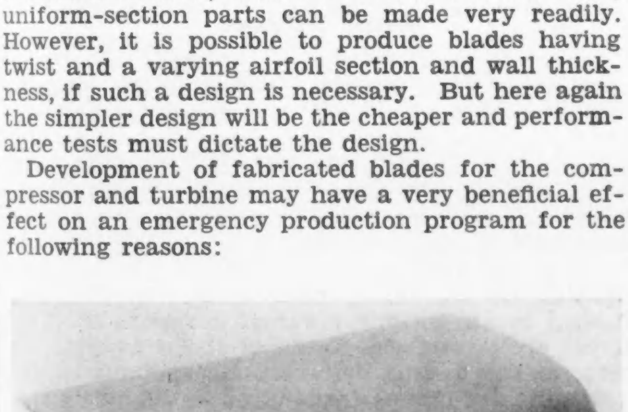


Fig. 2—This nozzle vane is of the fabricated type, formed from sheet stock

1. Press equipment can be light.
2. There is little waste of material.
3. Development of progressive dies is usually possible for high production.
4. Only moderately skilled labor is required after production tooling is developed.

Blades From Metal Powder

The powder metallurgy process was developed in an effort to use very little critical material and to employ only light equipment in the manufacture of axial-flow compressor blades and vanes. A special powder metallurgy technique makes it possible to work to close tolerances with non-critical, readily obtainable materials using relatively light press equipment. Powder-metal blades offer economies in manufacture in addition to the advantages originally sought.

In his process, powdered iron—made by reduction of crushed rolling-mill scale—is molded to shape in presses under approximately a 150-ton. See Fig. 3. The "green" compact, so made, is sintered at about 2000 F in a protective atmosphere and later coined to the precise airfoil contours required, as shown in Fig. 4.

At this point of manufacture an unusual practice

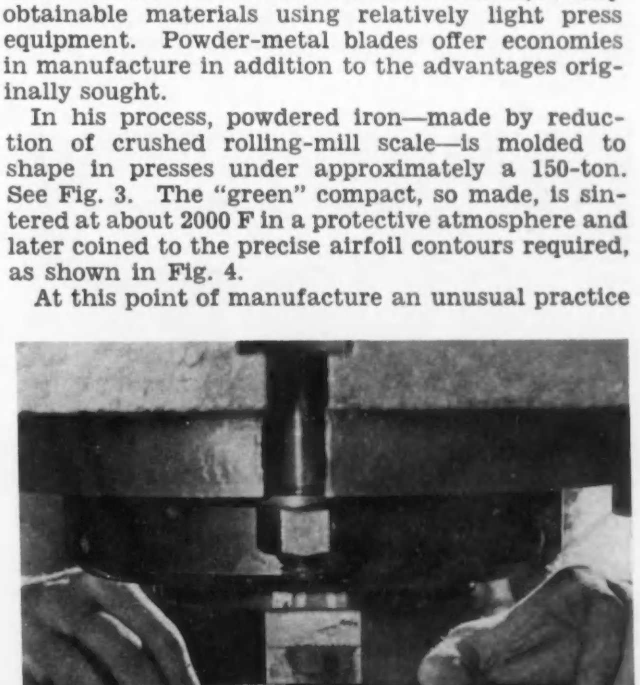


Fig. 3—Molding iron powder into a turbine blade. Note the completely molded part being held at right

Fig. 4—The sintered powder-metal blade is coined, as shown here, to give it precise airfoil contours

is employed: The precision-shaped part is reheated to about 2000 F in contact with a copper alloy in a special atmosphere furnace. The copper alloy is melted and absorbed into the porous iron compact largely by capillary action, producing an almost 100% dense part. In this step, alloying of the iron by the copper occurs and a heat-treatable iron alloy is formed. Fig. 5 shows parts at each stage of the process.

Fig. 5—Stages in the TP-1 powder process—from the iron scale to the finished blade

The corrosion resistance required in compressor blading is provided by a chromized case about 0.002 in. deep. Engine tests are currently being run to determine the suitability of a nickel-chromium electroplate to replace the chromized case in order to lower cost. The corrosion resistance afforded by chromizing or electroplating is superior to the standard Type 403 stainless material, as illustrated in Fig. 6.

The ultimate strength of the powder part is approximately 100,000 psi, which is less than standard blade materials. But extensive engine testing has proved the blades to be quite satisfactory. To date more than 500,000 axial-flow compressor stator vanes have been used in a current production jet engine. Test work on the use of powder metal for compressor rotor blades is now under way.

Aside from the method's principal advantages of low cost and the use of non-critical materials, are the requirements for only 250-ton standard presses, small work area, and high die life. Some 150,000 blades per month can be made in 12,000 sq ft of manufacturing space. Molding and coining dies are currently made of conventional tool steels and are giving a life of 75,000 to 250,000 pieces. Carboloy dies will probably yield 250,000 to 1,000,000 blades.

Excellent reproducibility of dimensions is indicated by the long die life. Working tolerances are currently ±0.003 in. to airfoil contour, ± ½-deg of twist, and ±0.010-in. deviation from theoretical CG line.

The surface finish obtainable with the chromized case is 50 rms maximum. Powder-metal blades with this finish are much smoother than the reading indicates because the surface discontinuities are indentations between flat plateaus rather than the usual "hills and valleys." These limits are within the acceptance requirements for all current engines, although 10 rms maximum is being considered by some designers. Powder-metal parts can be made to this requirement by low-cost polishing and electroplating.

Rolling Technique

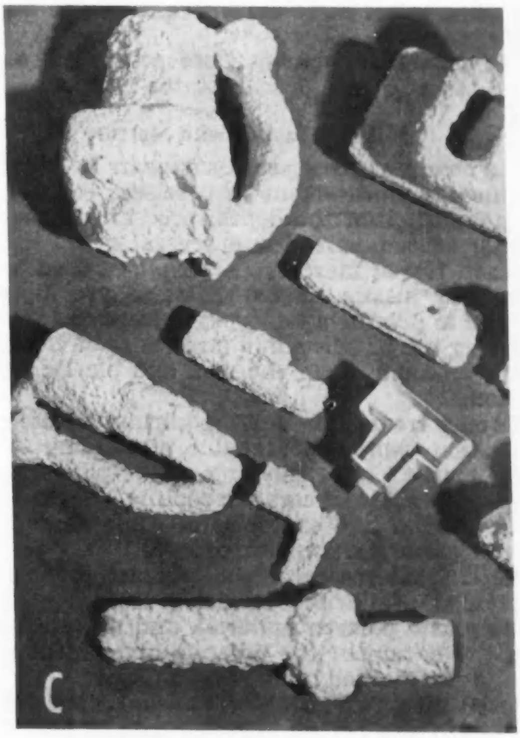
Borrowed from the cutlery industry, the rolling process has recently been adapted to the production of compressor blades. The similarity between the knife blade and the compressor blade is readily apparent, both having thin, wide cross-sections with an attaching device at one end. It is not surprising, therefore, that the same process can be used to manufacture both parts.

The rolling process offers somewhat better tool life than conventional forging because the metal is formed in an entirely different manner. Rolling forces excessive metal ahead of the rolls and can perform the desired deformation gradually, while in forging, the material is trapped in the die cavity, flowing against the die walls at high surface speeds and pressures.

While blades having a varying section and twist can be rolled, if the section is uniform from end to end, the operation can be continuous and is considerably cheaper. After being cut into the required lengths, the parts can be twisted if so desired.

The main problem with such blades is the means of attachment. As stationary vanes, they can be brazed, welded, or peened to shroud rings. As ro-

The Mercast Process

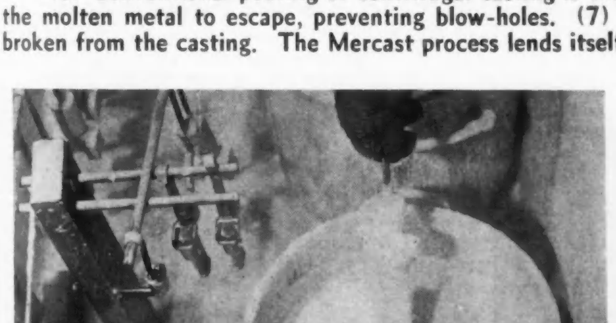


Here are the basic steps for making precision castings by the Mercast process:

(1) Liquid mercury is poured into a master mold made of metal or other material. (2) The mercury-filled mold is chilled in a bath at a temperature below – 40 F. (3) Frozen mercury pattern is then removed from the master mold. In "A" is shown a mercury pattern. With a complex product, a number of component patterns may be built into a complete pattern.

(4) The frozen mercury pattern then is dipped in a chilled refractory slurry made up of very fine ceramic particles. Several coatings are given the part, as shown in "B," until it has a ceramic shell of from $\frac{1}{8}$ to $\frac{1}{4}$ in. (5) When the shell-like mold is thoroughly dried in a cold box, the mold is removed to room temperature where the mercury melts out, and later fired in a kiln. See molds in "C."

(6) Conventional pouring or centrifugal casting is the next step. The mold breathes to allow air and gases in the molten metal to escape, preventing blow-holes. (7) When cool enough to handle, the thin ceramic mold is broken from the casting. The Mercast process lends itself to production of complicated parts, such as those in "D"



tating blades, a root must be formed by upsetting, brazing or welding. Caution must be exercised by the designer so that the resultant component, after assembly, is not more expensive than one made by other processes.

The industry is giving close attention to strip-rolled stock for compressor stator blades.

Precision Casting with Mercury

The recent Mercast process appears to be the first significant improvement in precision casting since the adaptation of the dental process of "lost-wax" casting to commercial use several years ago. In Mercast, frozen mercury patterns are used instead of wax or plastic. These patterns are dipped in ceramic to provide a relatively thin mold instead of investing the patterns in a large bulk of ceramic to make the mold, as in the wax and plastic pattern method.

Mercury freezes at - 40 F, requiring the use of refrigeration equipment capable of holding - 100 F continuously for the molding of the patterns, precoating storage, and ceramic coating. Several steps in the process and examples of parts produced by the process are shown on page 51.

The characteristics of the Mercast process may be divided into those resulting from the use of mercury as a pattern material, and those resulting from the nature of the ceramic investment material and the method of application.

Frozen mercury exhibits unusual cohesiveness. Two clean surfaces of solid mercury will weld together with very light pressures. This provides a very convenient and simple way of building up complex mercury patterns. Another advantage arises from the fact that the surface of the mercury pattern exhibits no concavity or sink resulting from shrinkage, a serious defect with wax patterns.

Because temperatures lower than - 40 F must be used with mercury patterns, water is not used in the ceramic slurry from which the refractory mold is built up. The problems arising from the necessity of driving off water are therefore eliminated.

Because the ceramic coat is built up to a thickness of only 1/8 to 1/4 in., the amount of refractory material required is far less than for the wax investment molds, where the whole flask is filled with investment.

The fact that the ceramic mold is thin has another important advantage. In hollow castings, the core is built up with the outside in the ceramic coating operation. Consequently the core, like the mold, is thin and offers little resistance to crushing with the shrinkage of the cooling metal around it, thereby avoiding distortion of the casting.

The process holds much interest for complicated hollow parts, such as turbine blades and vanes, particularly for new designs to improve heat transfer. Excellent surface finish can be obtained, and dimensional tolerances are about 50% closer than with the wax method.

At present more labor and dies are required in Mercast; but from a cost standpoint this may be offset by an appreciably lower scrap loss. The outstanding advantage of Mercast is the possibility of making close-tolerance complicated shapes, practically impossible by any other production method.

In case of national emergency, probably all of these seven processes will be used wherever they are best adaptable. For compressor rotor blades and stator vanes, precision forging, rolling and TP-1 powder process seem the best suited for large production, producibility, and low cost. Of these, the TP-1 process appears readily expanded, using light equipment, very little critical material, and limited space.

For turbine blades, the precision forging process appears best; but precision casting is useful for non-forgeable alloys and for hollow parts. Solid nozzle vanes may also be made either way.

For hollow nozzle vanes, precision casting or fabrication seems superior, depending upon the alloy used.

All of these processes are being used at the present time, the forging and lost-wax casting predominating. Good judgment by industry has resulted in giving each a thorough trial, so that the newer methods may be fully explored as to their usefulness. No one method has all the desired factors, and only continued experience will indicate the best overall processes.

(The paper also tells how blading design can affect producibility. Types of inspection equipment are discussed too.)

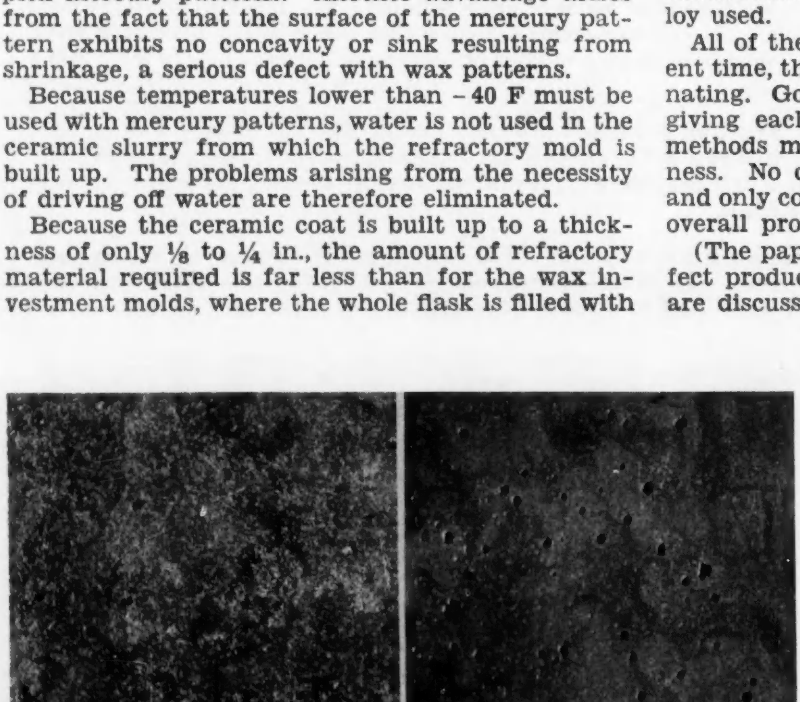


Fig. 6—This shows how the chromized TP-1 powder blade (at left) compares with the type 403 stainless blade (at right) in resistance to salt spray corrosion after 96 hr

Bus Service Failure Analysis

Nets 97% Efficiency In Buffalo Operation

BASED ON PAPER* BY

William W. Kunz

Superintendent of Equipment
International Railway Co.

INTERNATIONAL Railway's record of over 97% bus assignments completed stems largely from the company's where-what-why analysis of all aborted bus runs. This three-step program spots responsibilities for troubles, gains employee cooperation, and pinpoints failure causes.

Basic element of the analysis is the "pull-in," defined as any vehicle which for any reason does not complete the work assigned after leaving the garage.

First of the three steps is to find how many pull-ins each of the company's garages is responsible for. A monthly chart, compiled from daily pull-in reports from each location, is prepared which includes both mechanical and nonmechanical pull-ins. The mechanical department at each location makes the daily analysis.

The "what"step, second part of the program, consists of a tabulation of all pull-ins analyzed under five major headings. See Fig. 1. This chart breaks down total pull-ins experienced in any one month into: (1) total mechanical pull-ins, (2) okay pull-ins, (3) nonmechanical pull-ins, and (4) equipment involved in delay pull-ins.

The total mechanical pull-ins lists all those for which the mechanical department is fully or partially responsible. Okay pull-ins are those in which absolutely no defective equipment is even remotely involved. Under nonmechanical pull-ins are listed those in which the breakdown cause is not connected with mechanical department performance—such as accidents. The "equipment involved in delays" category covers total mechanical and nonmechanical pull-ins which delayed passengers on trips.

Step three in the analysis is aimed at explaining why the total monthly mechanical pull-ins happened. It sorts them into four groups to spot departmental responsibility for each, as shown in Fig. 2. The groupings are:

1. Breakdowns for which a mechanic is responsible.
2. Breakdowns charged to management policy.
3. Breakdowns which can be avoided or reduced with transporatation department help.
4. Mechanical breakdowns delaying equipment in service.

The mechanic is considered responsible for pull-ins occurring too soon after a preventive maintenance inspection or a shop repair. In each case the failure is called to the attention of the mechanic involved. This makes the mechanical force completely pull-in and performance conscious. Currently this type failure delays passengers on less than 1% of buses operated.

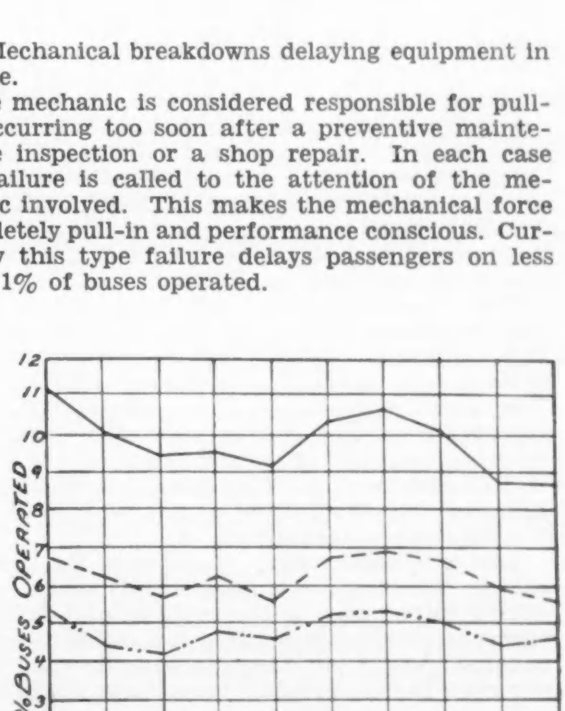


Fig. 1—International Railway Co. breaks down its bus pull-ins into four categories and keeps a monthly record of them

* Paper "Automotive Maintenance Engineering," was presented at SAE Buffalo Section, Dec. 15, 1949. (This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

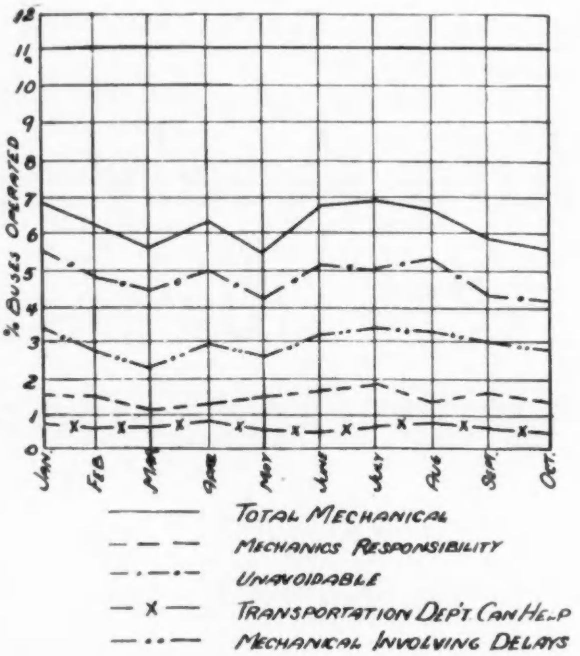


Fig. 2—Final step in International Railway's bus pull-in analysis is to classify mechanical pull-ins under these four headings on a monthly basis

Unavoidable pull-ins are those for which basic company policies are responsible. They include: too long an interval between inspection periods; improper equipment design; and attempts to get maximum life from consumable items such as electric light bulbs and motor brushes. Failures of this type presently delay passengers on less than 2% of the buses operated.

The transportation department can help cut third-category pull-ins by such things as not abusing equipment, realizing vehicle performance limitations, and preventing accidents. Although the mechanical department makes this analysis without even consulting the transportation department, only an insignificant portion of pull-ins is charged to this classification. Less than ½% of equipment operated fails from these causes, as against about 6% for mechanical failures.

This is a healthy sign. It indicates the mechanical man's willingness to shoulder his load.

This third phase is the most helpful because it places responsibility for failures, makes it possible to come up with suitable procedures to eliminate or minimize them. Proof of the system lies in its results. It fosters good employee morale and cooperation, spots design shortcomings, and reduces chronic troubles.

Placing pull-in responsibility directly on the mechanic, and telling him of it immediately, puts both foreman and mechanic on their toes. The foreman has to instruct his mechanics properly. The mechanic is not asked to perform the impossible. When the mechanic feels he is unjustifiably blamed for a failure, he can give the foreman the facts. The foreman can agree with the mechanic and sell management on looking for the real source; or he must show the mechanic how to do the job right.

This has reduced grievances. The individual mechanic's performance is compared with that of others doing similar work. The mechanic also has an honest opportunity to argue against unreasonable standards.

The transportation department has helped reduce pull-ins traced to it as well as driver gripes. Drivers are advised of the pull-in picture. Equipment abuses are called to their attention. They are told how they can help save manpower wasted in checking imaginary defects. The operator also is made familiar with limitations of certain equipment.

Discussing pull-ins with mechanics also discloses design details that inflate operating costs. Chief one is lack of accessibility. We have succeeded in making bus builders accessibility-conscious. Our latest buses are the very best from this standpoint.

The unavoidable pull-in classification brought about reconstruction of bus heater lines. Study of heating system failures showed they could be reduced by a few simple changes, such as in piping layout, eliminating parallel heating circuits, and repositioning poorly-located thermostats.

The study also revealed a general tendency of bus designers to build too much plumbing into the heating system. Passing these facts on to bus builders brought a real reduction in the number of fittings. Our latest buses have only two hose connections and 3 ft of piping, as against six hose connections and 74 ft of piping in earlier models.

An outstanding gain from the unavoidable pull-in analysis is the reduction in frozen air failures. Under the old method of operating, the mechanic usually was blamed for any frozen air failure shortly after a preventive maintenance inspection. It was felt he either failed to drain the air tanks or forgot to put in alcohol. After mechanics insisted they had done their work properly, this failure was reclassified as unavoidable.

But its frequency cast doubt on the old accepted cures of draining tanks and using alcohol. The engineering department was given the job of finding the answer.

Extensive tests during the summer, using dry ice, proved that frozen air was much more a function of air brake line design and housing facilities than anything else. Air line size was changed, controlled entirely by housing facilities available. Housing facilities determined how long a vehicle might accumulate frost in the air lines, before the thawing period could set in, so that the frost could drain to the tanks, from which it could be drained off while the vehicle was stored in a heated garage. Installation of air lines with sharp bends at expansion points also was eliminated.

Because of these changes, frozen air troubles were reduced 79% from the year before the test. On all new buses we specify the proper size air lines. Our standards have been adopted by most major bus manufacturers.

The pull-in analysis also helps better our preventive maintenance program. Many minor pull-ins, especially those caused by defects bordering on the imaginary, have helped detect failure trends delaying service. This keeps our preventive maintenance program flexible and up-to-date, to meet changing conditions and requirements of our service.

Secondary Vibrations

PART I –
In Front End Suspensions

EXCERPTS FROM PAPER* BY

Clark A. Tea
Ford Passenger Car Division
Ford Motor Co.

Light is shed on secondary vibration causes and cures in front end suspensions in this article by Tea. He shows the role played by shock absorbers, tires, sprung and unsprung weight, and the front stabilizer bar.

His data-backed interpretations point the way to design for better riding quality.

This, the first half of a two-part series on secondary vibrations, will be followed by an article on rear end suspensions in the July issue of the SAE Journal, by V. D. Polhemus, General Motors Corp.

SIX design factors influencing secondary vibrations in car front suspensions, unveiled in road tests and studies, indicate ways to improve riding quality. These secondary vibrations stem from wheel disturbances, imposed by road surface roughness, and transmitted to the body and frame as shake or harshness.

The six disclosures are:

1. Wheel hop is primarily a function of tire flexibility.
2. Lighter tire weight and increased radial flexibility are desirable in reducing wheel hop, shake, and harshness.
3. Good handling and riding qualities require high static deflection with balanced sprung weight distribution between front and rear ends.
4. Avoiding excessive body shake through impact and wheel hop calls for lower unsprung weight with increased spring flexibility.
5. Shock-absorber damping quality and quantity make a difference in control of wheel hop, shake, and body ride motion. The viscous shock absorber is very effective above 40 mph.
6. The front stabilizer bar tends to aggravate side shake and harshness.

Let us first focus on the tire's role in secondary vibrations. Since tire deflection is added to chassis spring deflection, the tire assumes an important part of the front suspension as a road shock absorber, cornering means, and noise insulator. With the trend toward larger and lower-pressure tires, the effect of the vertical vibration of the wheel and unsprung parts (wheel hop) upon ride is becoming less important in the suspension system. But this introduction of increased tire radial flexibility has aggravated the problems of fuel economy, tread wear, lateral stability, and steering efforts.

Although tire flexibility has increased from approximately 1620 lb per in. for a light car in 1930-1931 to approximately 1250 lb per in. in 1949, the suspension spring flexibility has increased in even greater proportion. Transmissibility ratio of wheel hop to body amplitude has actually diminished. With but little reduction in unsprung weight, the tire absorption capacity has increased in proportion to its static deflection. For example, at 40 mph over a given bump, total front wheel hop was reduced approximately 30% when the 28-psi tire pressure was reduced 28% to 20 psi. A graphic record of this effect is shown in Figure 1. Body amplitude also was reduced approximately 50%.

A series of road tests was made to determine the effect of tire size on side shake and harshness. Four different size tires were selected and installed in order on two similar lightweight cars of the same make. The tire and wheel assemblies were balanced and the cars tested over a 5-mile rough paved course at a critical shake speed using an electronic

*Paper "Wheel Hop and Shake Characteristics in Front Suspensions," was presented at SAE National Passenger Car, Body, and Production Meeting, Detroit, March 16, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Secondary Vibration Terminology

1. **Wheel Hop** is the vertical vibration of the wheel between the tire or road and suspension spring caused by a sudden change in the pressure between tire and road surface. It lies within a frequency range of 300 to 1200 cycles per min.

2. **Shake** is an intermediate vibration of the frame and/or body, usually felt in the seat cushion and steering wheel, and has sufficient amplitude to be readily visible. Its frequency range is within the wheel hop range of 300 to 600 cycles per min.

3. **Harshness** is the overall effect of high frequency —short amplitude vibrations within or between parts of the chassis in the range of 20 to 100 cycles per sec which is more or less associated with road noise.

shake meter, which indicated a total average amplitude independent of velocity. The results, shown in Figure 2, indicate in addition to the average shake amplitude, the observed relative harshness in numerical order.

So many factors are involved in these tests that only this one definite conclusion can be drawn from the results: Lightweight and high flexibility both tend to minimize side shake and harshness.

Next consideration is the sprung weight distribution and effect of unsprung weight. Both are important factors in car riding qualities and in control of wheel hop, particularly in sudden starts and stops.

For theoretically ideal sprung-weight distribution, the centers of percussion in a vertical and horizontal plane would fall at the wheel centers; also it is especially important that the same or slightly more (about 10%) weight be on the front wheels with the car empty. With a full passenger load, then the loads on the front and rear wheels would be approximately equal.

Under such conditions, the front and rear suspensions can be controlled independently of each other; there is no serious reaction from one end of the car to the other as a result of road bumps, and no resonance. But it is being sufficiently approached in most current production cars, so that with good damping control and sufficient sprung to unsprung weight ratio, a "flat" ride is not difficult to attain.

Best ride and handling will result with higher static deflection in front and a sprung weight distribution of front to rear of 1.25 to 1.5. In this way wheel hop forces are absorbed more completely and the lower pitching mode of vibration is brought into play initially.

In general, unsprung weight should be kept low. This will keep low unsprung vibratory forces in all planes with a minimum of shake, other things being the same. Reducing unsprung weight in a car simply raises the speed at which the tire loses contact with the road surface, and does not necessarily improve ride, although shake is reduced. Excessive unsprung mass calls for stiffer suspension springs.

Fifth fact disclosed by tests concerns shock absorbers. They must be depended on to control free body vibration and to dampen out wheel hop. Because of this dual requirement, type and quantity of damping control (usually 20 to 30% of critical) is most important for a good compromise between riding comfort and handling.

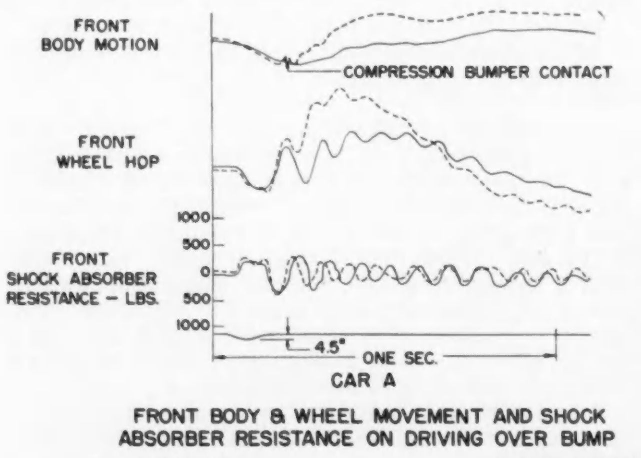


Fig. 1—Reducing tire pressure from 28 to 20 psi cuts front wheel hop 30% and body amplitude 50%, these road test data show

Wheel Hop and Shake Measured

Wheel hop and shake measurements, taken on the road under actual driving conditions, show the influence of shock absorber control and the effect of the front stabilizer bar.

A photographic oscillograph with suitable integrating and amplifying equipment and pick-ups were installed in two typical lightweight cars. Strain gauges were cemented to the shock absorber rods at their extreme upper ends. Specifications of the two cars, A and B, are given in Table 1.

Car A was tested over an artificial depression 110 in. long and 4½ in. deep, at several speeds and under different conditions. This same car also was tested over a typical rough road course used for shake study under somewhat similar conditions. Car B was tested over a similar type of bump, but of different shape.

Two different types of shock absorber were used to show the effect of damping control on front wheel hop, vertical and pitch amplitudes, and horizontal and vertical shake. The effect of the front roll bar also is shown.

Fig. 3 shows records of the shock absorber resistance, front wheel hop, and body amplitude of Car A, with standard orifice and blow-off type direct-acting hydraulic shock absorbers, at 20, 30, and 40 mph over the bump. These and subsequent tests were conducted with only the wheels on one side of the car running over the bump.

Shock absorber resistance increases with speed, as expected, especially between 20 and 30 mph. Wheel hop increases sufficiently for the tire to completely lose contact with the ground above 20 mph, and body amplitude is diminished in proportion to speed due to the shorter time of passage over the bump. The shock absorber follows the wheel hop and its motion is governed by the wheel hop frequency.

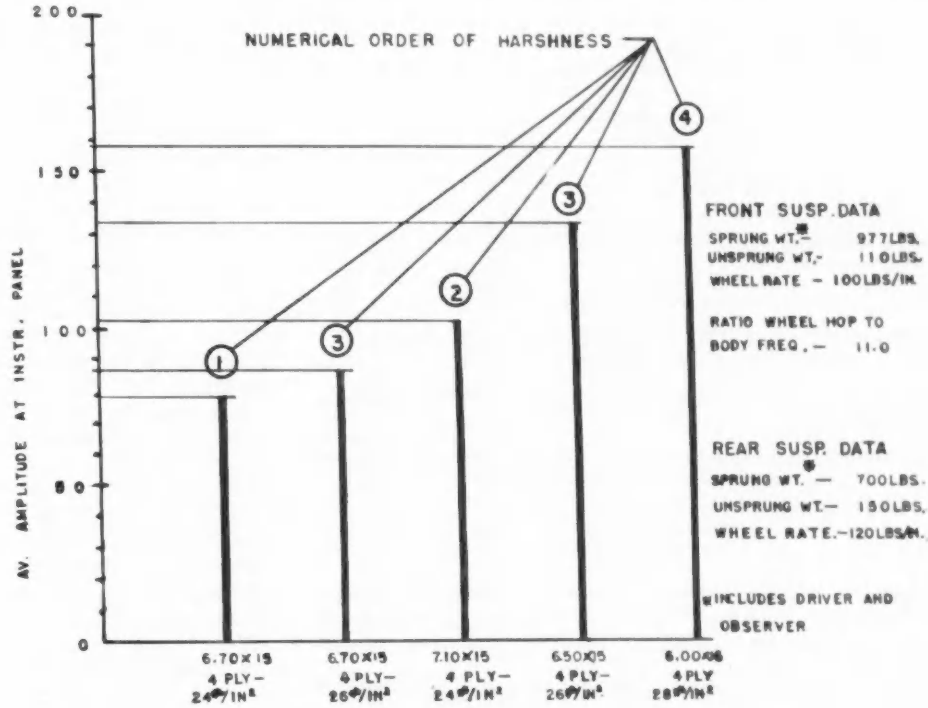


Fig. 2—Testing various tire sizes and pressures showed that both light weight and high flexibility tend to minimize side shake and harshness

Fig. 4 shows the velocity-resistance curves of the standard type shock absorber used in these tests as well as those of a viscous type, which were compared with the standard for effect on wheel hop and body amplitude on the bump test. Basic difference between these shock absorbers is in the velocity-resistance characteristics. The viscous type shows a high linear speed build-up due to a restriction in the valve passage after the initial lifting of the static pressure blow-off. The only exception to this is in the rear compression, which is due to deliberate use of conventional valving.

It is not true viscous damping because a blow-off is used in the valve arrangement to provide a needed coulomb, or "static" damping effect, for the intermediate wheel hop velocities. The effect of the viscous shock absorber damping at 30 mph, shown in Fig. 5, is to suppress wheel hop and decrease body amplitude.

This speed is approximately critical for pitch, since at 30 mph, pitch almost equals front bounce frequency. This can be determined from the expression:

$$f = \frac{180\,V}{S}$$

where:

S = wheelbase in inches
V = road speed in ft per sec
f = pitching frequency in cycles per sec

At this speed, the viscous control is especially effective. Maximum compression and rebound re-

Table 1—Test Car Specifications

	Car A	Car B
Wheelbase, in.	118	114
Curb Weight, lb	F-1910 T-3350	F-1845 T-3240
Unsprung Weight, lb	F-222 T-524	F-220 T-520
Front Wheel Rate (less tires), lb per in. (normal load)	91	125
Rear Wheel Rate (less tires), lb per in. (normal load)	125	127
Front Roll Rate (less tires), ft-lb per deg (normal load)	309*	329*
Rear Roll Rate (less tires), ft-lb per deg (normal load)	206	195
Percent Front Sprung Weight over Total (curb)	59%	60%
Percent Front Sprung Weight over Total (normal load)	55%	54%
Percent Front Roll Rate over Total (normal load)	60%	63%
Tires:	7.10 × 15—4 Ply	6.70 × 15—4 Ply
Front Tire Rate, lb per in.	1260	1240
Rear Tire Rate, lb per in.	1260	1120
Tire Pressure, Psi	24	24 F—21 R

*Including Roll Bar; Roll Bar = 111 ft-lb per deg Car A
Roll Bar = 86 ft-lb per deg Car B

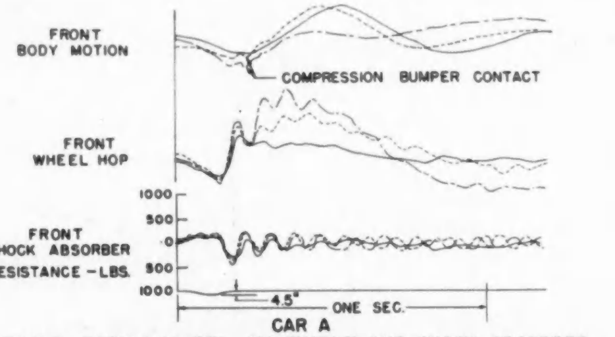


Fig. 3—In bump tests, both shock absorber resistance and wheel hop increased with speed above 20 mph

sistances of the viscous shock absorber reach approximately 600 and 700 lb, respectively, maximum compression and rebound for the standard shock absorber is 300 lb.

Fig. 6 shows that the roll bar in front is a disadvantage as regards wheel hop and body amplitude when going over staggered bumps. This makes it desirable to keep the stiffness of the bar to a minimum. Some bar, however, is always a necessary part of the parallel link independent suspension to balance roll rates between the front and rear suspensions for safe steering and handling.

A second series of tests was conducted on Car B over an oblong depression 4½ in. deep by 30 in. long, cast in a concrete runway. The bump itself resembles a typical broken-out section of paved highway.

Equipped with the same standard (orifice and blow-off type) shock absorbers, records of front and rear shock absorber resistance, wheel hop and body amplitude were obtained at 10, 20, and 40 mph. Average results at the three speeds are compared in Fig. 7. Vertical body amplitude is a maximum at 10 mph and its motion is quite independent of the rear end forced vibration.

The ratio of wheel hop frequency to body frequency is 9 to 1, which confirms the calculated data from Table 1. It is fairly consistent for 20 and 40 mph. Above 10 mph the compression impact increases in severity. It reaches a maximum at 40 mph where the front wheel engages the bottom of the bump and the far wall simultaneously.

Above 40 mph, the wheel does not have time to reach the bottom of the bump; the impact gradually lessens and body rise diminishes until finally very little disturbance exists at all. Obviously the wheels receive a double impact at 10 mph. And at all three speeds bottoming on the compression bumper is in evidence. Shock absorber motion follows the wheel hop as usual and the resistance increases with speed, up to the leveling off point.

Figs. 8 and 9 compare the viscous and standard shock absorbers as to their effect upon front wheel hop and vertical body amplitude of Car B at 20 and 40 mph. At 20 mph there is very little difference in the wheel hop or body amplitude. But the measured 1200-lb viscous shock-absorber compression force does dampen out the wheel hop faster.

At 40 mph, the viscous shock absorbers hold the wheels out of the bump. This reduces the impact force, very rapidly damps the hop, and flattens out the body motion. Much less shock and vertical shake was experienced with the viscous control as compared to the standard type.

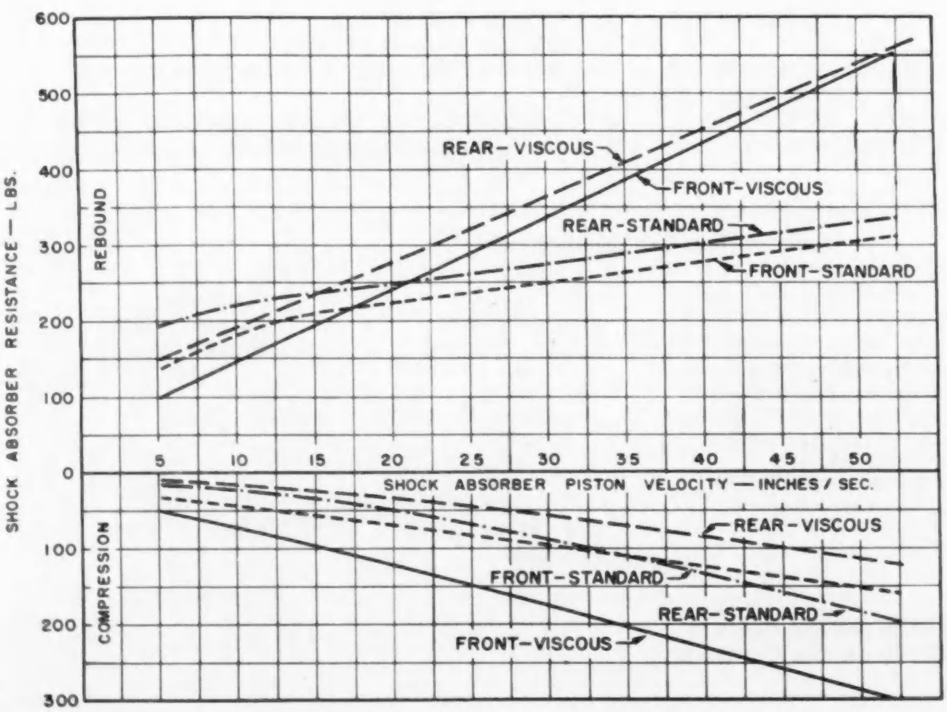


Fig. 4—These shock absorber velocity-resistance curves show a higher linear speed build-up for the viscous type, except the rear compression which is conventional

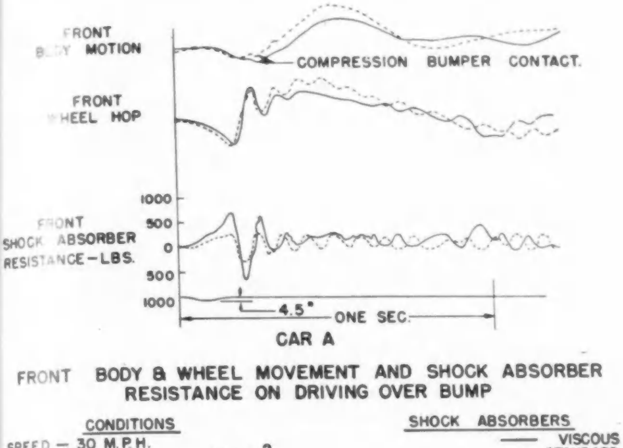


Fig. 5—The viscous shock absorber does a better job of damping wheel hop and body amplitude than the standard type, in this bump test conducted at 30 mph

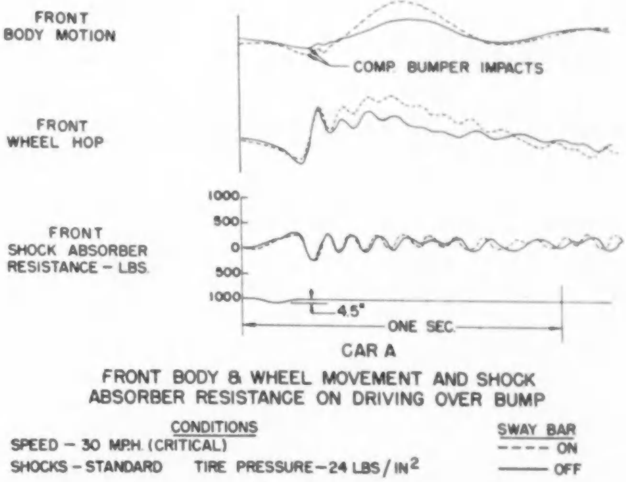


Fig. 6—With sway bar off, wheel hop and body amplitudes were less in bump tests than with the bar on. For this reason suspension designers attempt to make the bar less stiff

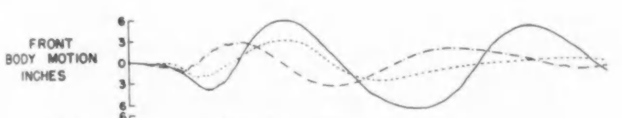


Fig. 7—Another series of bump tests, taken at three different speeds, produced the greatest vertical body amplitude at 10 mph

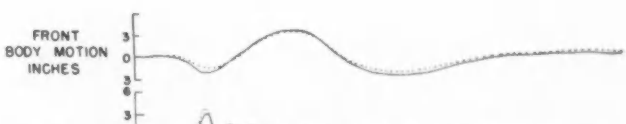


Fig. 8—At 20 mph there is little difference between the damping effects of viscous and standard type shock absorbers on wheel hop or body amplitude

Unfortunately, capacity of the conventional shock-absorber testing machine is far below the 2000-lb resistance of the viscous shock absorber recorded in this test. But there is no reason to doubt that the linear relationship, shown in Fig. 4, continues far beyond the limit of the testing machine.

Fig. 10 shows an interesting comparison between front and rear wheel hop, and front and rear body motions at 40 mph. Rear wheel hop is damped out very quickly as compared to the front hop with both types of control; but its total amplitude is only half as much. Ratio of rear wheel hop to rear body frequency is approximately 6 to 1, compared to 9 to 1 for front wheel hop to front body frequency. The reason for this difference is that the rear wheel hop frequency is only 70% of the front, while the rear bounce frequency is about 15% greater than the

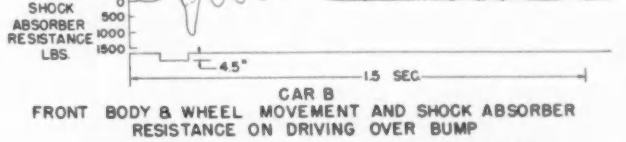


Fig. 9—At 40 mph the viscous shock absorber attenuates wheel hop and body motion better than the standard shock

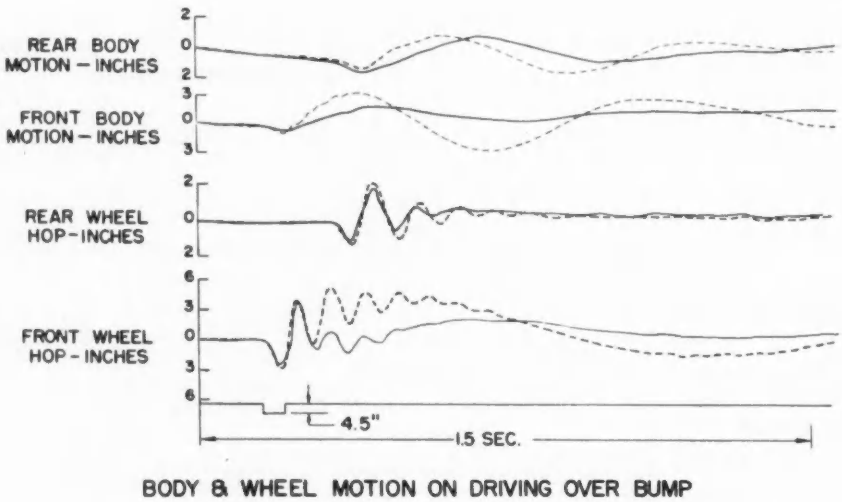


Fig. 10—This chart compares front and rear wheel hop and body motions with the viscous and with the standard type shock absorbers

front. Forty miles per hour is near critical speed for Car B, as shown by the body motion curves, which represent essentially a pitching motion.

Using the photographic oscillograph, runs of 30, 40, and 50 mph were made over a convenient stretch of rough road surface to get experimental data on body and frame shake and front wheel hop. Both types of shock absorbers were compared, and effects of roll bar and 20, 24, and 28-psi tire pressures were recorded.

Analysis of the records obtained, compiled in Table 2, yielded the following general trends:

1. Viscous type shock absorbers tend to increase horizontal and vertical shake and wheel hop but very slightly up to 40 mph. Above 40, the viscous control is very effective in attenuating shake and wheel hop. Overall ride and control also is definitely better at the higher speeds with viscous control. This experience has been quite generally true.

2. Vertical body shake and wheel hop increase with tire pressure at all speeds; but body side shake is a minimum at 24-psi standard tire pressure through the 30 to 50-mph speed range.

3. The roll bar shows a definite tendency to increase side shake without affecting vertical shake greatly. This is so because the roll bar forces the body into a roll vibration, which sets up horizontal periodic forces while tending to permit greater freedom in a vertical direction.

Many other trends might be drawn from the tabulated results, although the conditions are too specific to warrant drawing broad conclusions.

Table 2—Road Test Data on Front End Shake and Vibration

Conditions				Averages of Shake Amplitudes—Inches			Front Wheel Hop
				Instrument Panel			
Speed mph	Tire Pressure	Sway Bar	Shock Absorbers	Vertical	Horizontal	Frame Vertical	Inches
30	20	on	std.	0.0108	0.0130	0.0218	0.746
30	24	on	std.	0.0138	0.0110	0.0177	0.596
30	28	on	std.	0.0154	0.0133	0.0322	1.340
40	20	on	std.	0.0098	0.0162	0.0257	1.25
40	24	on	std.	0.0163	0.0144	0.0228	1.476
40	28	on	std.	0.0220	0.0217	0.0403	2.070
50	20	on	std.	0.0111	0.0168	0.0284	0.952
50	24	on	std.	0.0161	0.0172	0.0390	1.334
50	28	on	std.	0.0237	0.0206	0.0308	1.792
30	24	off	std.	0.0146	0.0105	0.0174	0.656
40	24	off	std.	0.0163	0.0131	0.0232	0.920
50	24	off	std.	0.0144	0.0126	0.0371	1.690
30	24	on	viscous	0.0163	0.0106	0.0194	0.816
40	24	on	viscous	0.0149	0.0190	0.0292	1.754
50	24	on	viscous	0.0127	0.0151	0.0269	0.968

Rapid-Compression Technique Aids Understanding of Knock

BASED ON A PAPER* BY

C. F. Taylor, E. S. Taylor, J. C. Livengood, W. A. Russell, and W. A. Leary

Massachusetts Institute of Technology

Presented here are the highlights of a paper on the investigation of fuels with the rapid-compression machine developed at the Sloan Automotive Laboratory of M.I.T.

The complete paper, which was published in the April issue of SAE Quarterly Transactions, includes an impressive collection of 10,000-frames-per-sec photographs taken during the burning of both leaded and unleaded *n*-heptane, isooctane, *n*-butane, and unleaded benzene under varying conditions of temperature, compression ratio, and fuel/air ratio.

Records of pressure versus time and also a few of piston motion versus time are included. In some cases, the pressure-time records were taken simultaneously with the flame photographs, so that changes in pressure could be correlated with the flame development.

The rapid-compression machine is thus making possible the development of a new technique for studying the combustion process. In particular, it is adding immeasurably to our understanding of detonation—what it is and how we can eliminate it.

The authors stress that their work so far has been mainly exploratory in nature—to sample the various regions of the field. They look forward to the construction of more rapid-compression machines, which can be used by other research workers to help in investigating the steadily growing list of combustion phenomena that need to be studied.

THE autoignition theory of detonation—which says that knock occurs when autoignition of the end gas (that is, the unburned portion of the charge ahead of the flame front) occurs so suddenly as to give rise to intense pressure waves—would appear to have been given a corroboratory boost by a series of tests with various fuels in a rapid-compression machine.

This machine, which is shown in Fig. 1, was designed to compress a fuel/air mixture in a manner similar to that which occurs in the end gas of an engine. However, the end gas in an engine is compressed continuously by the expanding gases behind the flame front, whereas in the rapid-compression machine the mixture, which may be considered as all "end gas," is compressed only to a predetermined pressure and, as a result, the preliminary stages of the autoignition process are slowed down to the extent that they can be readily studied. The compression rate of the machine corresponds to the compression rate of the end gas in a high-speed engine. The pressure-time history of the entire process and the development of the inflammation following the compression are recorded by means of an oscillograph and a high-speed camera.

The length of the period between the end of compression and the moment when the explosion occurs or maximum pressure is reached—the delay period, as it is called—depends on several factors. General trends found to be characteristic of most of the fuels tested so far are:

1. The longest delays are observed at very lean and very rich fuel/air ratios. Between these two extremes the delay passes through a minimum, but the fuel/air ratio at which this minimum occurs is not sharply defined.
2. The delay period decreases with an increase in compression ratio.
3. The delay period decreases with an increase in initial temperature.
4. At very lean or very rich fuel/air ratios the explosion is relatively mild. At intermediate fuel/air ratios it is more violent.

* Paper, "Ignition of Fuels by Rapid Compression," was presented at SAE Annual Meeting, Detroit, Jan. 10, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

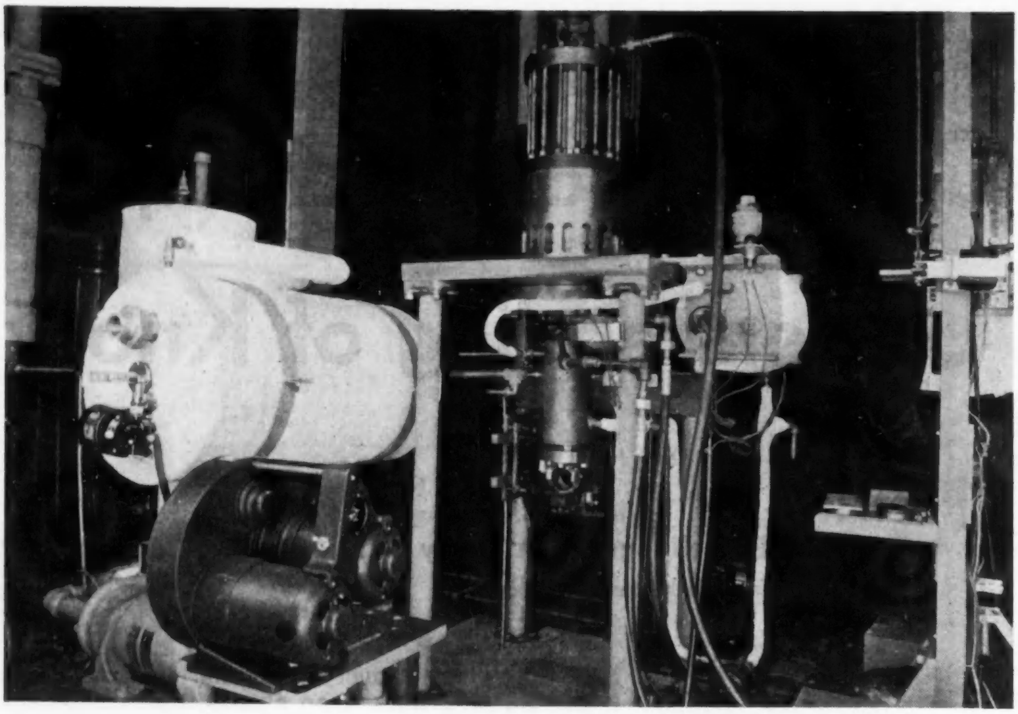


Fig. 1—General arrangement of apparatus

High-speed motion pictures taken of the inflaming fuel/air mixture in the cylinder during this period indicate that autoignition can occur in a variety of ways—in fact, no two flame sequences are exactly alike, even when taken under the same test conditions. The various types seem to fall into three rather loose classifications, however, which may be summed up as follows:

1. The inflammation is first recognized as a faint glow more or less uniformly distributed throughout the combustion chamber. As the reaction proceeds, the intensity of the emitted light increases until a point of maximum brilliance is reached. The intensity then fades away gradually.
2. The inflammation first shows up as one or more isolated points of light. As the reaction proceeds, these points grow in size, while new points develop sporadically in all parts of the chamber. This process continues, with each point growing and combining with neighboring points until the mixture is completely inflamed.
3. The inflammation begins in a small region and progresses across the chamber in the form of a flame front. In many instances multiple flame fronts are formed.

The photographic records also show that a correlation exists between the rate of inflammation and the rate of pressure rise in the corresponding pressure-time record.

Other trends noted in the data collected with the aid of the rapid-compression machine include the following:

1. Tetraethyl lead affects the delay and the rate of inflammation of all the fuels tested except benzene. The lead effect varies greatly with initial temperature and, in the case of *n*-heptane, the effect on delay and rate of inflammation below 200 F is the reverse of the effect on delay and rate of inflammation at an initial temperature of 310 F.
2. When ethyl nitrite—a knock inducer—is added to triptane it decreases the delay and increases the rate of pressure rise in the last stages of the reaction.
3. In general, the autoignition of *n*-heptane is relatively rapid, while that of benzene is relatively slow and that of isooctane is intermediate.
4. The autoignition of *n*-heptane sometimes proceeds in two stages, especially at lean fuel/air ratios. Tel increases the duration of the second stage. This same phenomenon has been observed in a CFR engine running with compression ignition of a premixed charge. A two-stage autoignition reaction has also been observed for isooctane.

Correlation with Actual Engines

The rapid-compression machine has been successful in giving a physical explanation as to why certain operating variables affect the detonation tendencies in engines. It is known that engine detonation, or knock, can be reduced by:

1. Lowering the inlet temperature.
2. Lowering the compression ratio.
3. Running at rich or lean fuel/air ratios.
4. Adding tetraethyl lead.

It has been shown by the authors that fuel/air mixtures subjected to these same variables in the rapid-compression machine result in a long delay and a slow rate of pressure rise. This is just what would be expected, according to the autoignition theory since, roughly speaking, a long delay in the end gas of an engine should enable the flame to pass through the entire charge before the end gas has time to autoignite; and, under circumstances where autoignition does occur, a slow rate of pressure rise should cause less intense pressure waves than would be caused by a rapid one.

Modified Prop Blade Cuts De-Icing Heat

Based on paper by

VERNON H. GRAY

National Advisory Committee for Aeronautics

(This paper will be printed in full in SAE Quarterly Transactions.)

BLADE segment redesign of a gas-heated propeller brought an 85% saving in heating requirements without impairing the ice-prevention job.

Fig. 1 shows the hot-gas flow through the hollow-bladed propeller. The gas, heated at a suitable source, passes through a manifold and collector rings to cuffs on the blade shanks. It then flows radially outward through the hollow blade. Internal partitions confine flow to the forward portions of the blade. The gas leaves through a discharge nozzle at the blade tip.

Big design problem with gas-heated propellers is to prevent ice formation with the least amount of heat.

The original blade design gave way to the modified one, shown in Fig. 2, as a result of analysis and tests. Additions include internal metal fins attached to the leading edge and another partition.

The fins increase the effective internal heat-transfer area and conduct heat into the leading edge region. The added partition reduces the flow-passage area. It confines flow to the blade fore part, yet allows some heat transfer near the chord mid-point.

This design halves the internal flow passage area and doubles the effective heat-transfer area. Internal flow is cut to 15% of its original value, yet total heat transfer through the blade segment remains the same. This represents an 85% saving in heat input together with a reduction of 70% in gas velocity and 20% in friction pressure loss.

Analyses and experiments that produced this solution are detailed in the paper. (Paper "Heat Requirements for Ice Prevention on Gas-Heated Propellers," was presented at SAE Annual Meeting, Detroit, Jan. 11, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

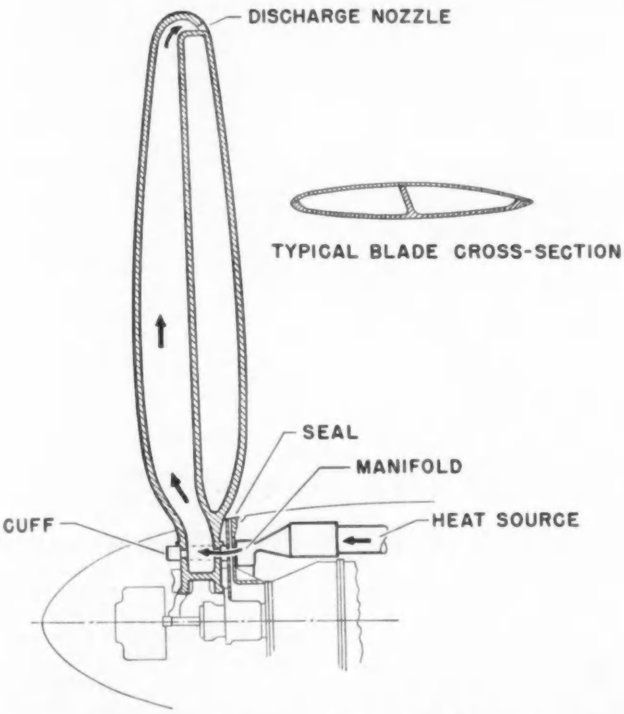


Fig. 1—Schematic flow diagram for hollow blade of a gas-heated propeller

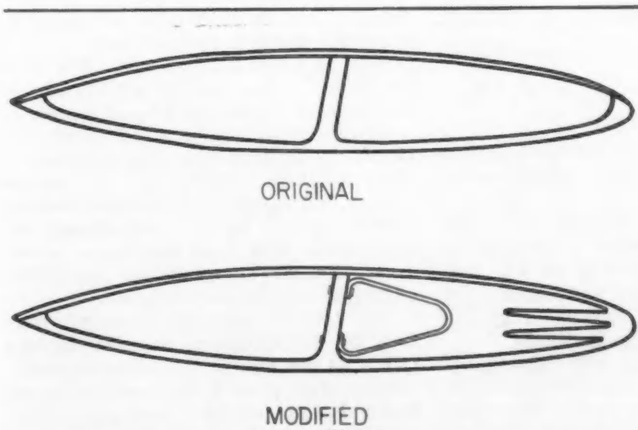


Fig. 2—Changing the internal blade design from that on top to the one below cut heat requirements 85%

Fuel-Engine Factors Affect F/A Mixing

Based on paper by

R. W. DONAHUE and R. H. KENT, JR.

Sun Oil Co.

(This paper will be printed in full in SAE Quarterly Transactions)

TESTS made with a typical postwar 6-cyl stock engine to find the engine and fuel factors involved in uneven distribution of fuel and air to various cylinders of a multicylinder engine showed that:

1. Increased speed gave a slightly improved distribution, probably because higher engine speeds tend to equalize distribution as a result of increased turbulence and velocity of the mixture. When the particular engine tested was run at 1500 rpm, however, distribution was poorer even than at 750 rpm. It is not particularly surprising that a point of inflection is reached where distribution is unusually poor, for there are numerous possibilities for resonance in the induction system.

2. Increasing the inlet air temperature seemed to be only mildly effective over what might be considered the practical temperature range. Similarly, increasing the hot-spot temperature from 93 F to 137 F had little effect on the spread in air/fuel ratio among the various cylinders. (Incidentally, elevated air and hot-spot temperatures caused engine power to be about 5% below normal as a result of decreased volumetric efficiency.)

3. Comparatively minute details of the induction system, such as the position of the choke valve and its mounting, and any other obstructions in the air passage, had a marked effect on distribution.

4. Relatively large changes in fuel volatility had only a minor effect on distribution. This result (which had been reached in earlier published studies, too) is contrary to the popular notion that distribution is, to a great extent, dependent on fuel volatility and can be largely controlled thereby. In line with this conclusion, the tests showed that the lightest components of fuels are unevenly distributed, as well as the heavier ones.

5. The antiknock quality of the fuel reaching each cylinder depended, to a large extent, on the variation in octane quality with boiling range of the original fuel. This quality can be controlled largely by maintaining even quality between the light and the heavy fractions of the fuel.

It is emphasized that, although some of these conclusions merely verify results reached by earlier workers, the remainder has been drawn by the authors as the result of work on just one engine. Thus, further work will be needed before the conclusions can really be considered general. (Paper, "A Study of Mixture Distribution in a Modern Multicylinder Engine," was presented at the SAE Annual Meeting, Detroit, Jan. 10, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Suggests Laying Open Brake Lining Unknowns

Based on paper by

J. G. OETZEL

Warner Electric Brake Mfg. Co.

(This paper has been printed in full in SAE Quarterly Transactions.)

IT'S time we determined brake lining limitations because we're operating these materials in the zone of diminishing returns. But it is not an easy job.

Lining wear rate is not readily definable. It depends on factors such as temperature and pressure. Only isolating each variable will uncover its effect.

Test results can't be easily correlated for two reasons. It is hard to measure surface temperature accurately. And tests vary as to temperature-measuring set-ups.

Proper selection also depends on knowing lining characteristics in the wear as well as destructive ranges. Yet most tests are in the destructive range, which doesn't reveal true lining performance.

No short test seems to show characteristics of a piece of lining. No one coefficient really represents a lining, because the coefficient varies widely with temperature, pressure, and degree of service curing. Linings curing on a shelf for one and one-half years differ greatly from freshly-made green ones.

Since lining characteristics can't be reduced to a simple index number, combining laboratory and road test results will form the best basis of judgment.

The paper also presents test data showing the effect of temperature, pressure, arc length, and speed on lining characteristics. (Paper "Brakes and Brake Lining Characteristics," was presented at SAE Annual Meeting, Detroit, Jan. 12, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Better Oils with V. I. Improvers

Based on paper by

C. L. FLEMING, JR., B. W. GEDDES, N. V. HAKALA, AND C. A. WEISEL

Standard Oil Development Co.

(This paper will be printed in full in SAE Quarterly Transactions)

VISCOSITY index—an arbitrary measure of the change in viscosity of an oil with temperature—can be increased by the addition of certain additives. With such improvers it is possible to make crankcase oils with a V.I. well above that considered practicable for straight mineral oils produced by the most efficient refining methods.

Although crankcase oils containing additives to give V.I.'s of 120-125 have been in use for many years, there has been some question as to the effect of the improvers on the performance characteristics of the oils. It was not certain that these improvers actually did impart to an oil the low-temperature starting and the oil consumption properties that had been anticipated, under actual service conditions.

Cold-starting characteristics of the oils were studied with the aid of cold-room tests and oil consumption properties were studied by means of both chassis dynamometer and field tests. These tests showed that:

1. High V.I. motor oils offer the readiest means of combining good low-temperature starting characteristics with low oil consumption properties in a single crankcase lubricant.

2. The low-temperature starting properties of high V.I. oils containing certain improvers are identical with those of straight mineral oils having the same viscosity at the low temperature under consideration.

3. The oil consumption properties of high V.I. oils containing improvers are identical with those of straight mineral oils having the same viscosity at 300 F. (Paper, "The Performance of High V.I. Motor Oils," was presented at the SAE Annual Meeting, Detroit, Jan. 10, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Easy Method Tells Truck Performance

Based on paper by

A. F. STAMM and E. P. LAMB

Dodge Truck Division, Chrysler Corp.

(This paper has been printed in full in SAE Quarterly Transactions.)

THE fleet man can select the truck best suited for his particular operation by a simple method for predicting grade ability at given road speeds. It's done by finding total vehicle resistance, in horsepower, from charts and tables.

These performance predictions depend on finding the components of total resistance power—air resistance, rolling resistance, and chassis friction. The difference between developed engine power and total resistance power gives the power available for grade climbing and/or acceleration.

The method also requires information or estimates of vehicle factors (such as net engine brake horsepower, frontal area, gross weight, and axle and transmission ratios) and operating conditions (such as altitude and road type and condition).

With these data, the fleet operator can forecast:

1. Vehicle grade-climbing ability at a given road speed.

2. Top vehicle speed on a level road with specified chassis units.

3. Potential top vehicle speed attainable with ideal chassis units.

The paper, upon which this article is based, works out examples for each of these cases. It presents the tables and charts for finding empirical factors in the expressions for component resistances. (Paper "A Method of Predicting Road Performance of Commercial Vehicles," was presented at SAE Annual Meeting, Detroit, Jan. 13, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Various Traffic Surveys Made for Road Planners

Excerpts from paper by

C. M. HATHAWAY

Illinois Division of Highways

TRAFFIC surveys made to aid in highway design range from a simple examination of a page of field notes to a very complicated and laborious analysis of a great mass of material.

The simplest form of traffic survey is that made to determine volumes of traffic. Maps are prepared showing traffic volumes on State, county, and rural roads.

Simple volume counts are also made at intersections of streets or highways and at grade crossings to determine whether signs, signals, or separation of grades are necessary. The turning movements are usually recorded, so that it will be known how to install signs, what intervals should be used if signals are installed, and the type and design of ramp approaches in the case of a grade separation.

Closely related to volume counts are studies of the weight of vehicles, principally of trucks and buses. Obviously, a pavement cannot be designed intelligently until the number, size, and weight of the vehicles which will use it are known. When vehicles are weighed in connection with a traffic study, it is customary to record, in addition to the weight and size of the vehicle, the commodity which it carries and its origin and destination.

More complicated than the first two types of traffic studies, but providing more detail, is the road-use type of survey. This type of survey is conducted by personal interview of a representative sample of motor vehicle users. From these studies, it is determined who uses the roads of various types, why they use each road or street (that is, for business or recreational purposes), the gasoline consumption of different types and ages of vehicles operated on the different types of road surfaces, the average travel of different vehicles, and many other items useful to the planner and designer. Fortunately, it is not necessary to repeat a road-use survey at short intervals, because travel habits have become sufficiently stabilized that the results of a survey may be utilized for several years.

The most complicated type of traffic survey is a complete urban study. This type of survey is determined by personal interview of car and truck drivers to determine the origin of their trip, its destination, its purpose and other incidental details. It may include not only transportation by passenger car, but also details of mass transit use, including bus, streetcar, railway, water, and air transportation. In large metropolitan centers, these studies may cover several cities and the urban and rural areas, if any, separating them. They require careful planning and execution and usually cover a period of one or two years. The results of these studies, however, justify completely their cost and the effort expended in making them. They provide not only the data needed to locate major and secondary traffic arteries in and between the cities, but also provide data essential to intelligent city planning of many varieties.

Other types of traffic studies, generally classed as special, are those intended to determine the capacities of different types of highway and street improvements, those used to study the passing practices of vehicles on congested highways, studies to find out how trucks perform on grades of different degrees, studies of the effect on traffic of the installation of signs or signals, studies to determine traffic delays caused by the blocking of roads or streets by train movements or railroads, and many other studies used in highway administration and design. (Paper "Highways" was presented at SAE Central Illinois Section, Oct. 31, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Modern Spark Plugs Permit Wider Gaps

Based on talk by

C. C. CIPRIANI

The Electric Auto-Lite Co.

THE electric ignition system is responsible to a large degree for the efficiency, low weight per horsepower, and convenience of operation which makes the internal combustion engine predominate in modern times.

The electric ignition system provides the means for rapid combustion—and rapid combustion makes possible the high-speed engine with its attendant advantages in efficiency and low weight per horsepower. Also, the electric ignition system in combination with the electric starting motor provides a convenience of operation unequalled by any other form of motive power.

Auto-Lite, as a manufacturer of all components of the ignition system, has always stressed the interdependency of these units for most satisfactory performance. One reason for this is that, as the spark plug ring firing tips become fouled and provide a lowered resistance to ground, the voltage of which the coil is capable depreciates markedly. Also, the voltage required by the spark plugs at road loads and wide-open throttle for new plugs and for plugs which have operated the equivalent of 10,000 miles is quite different. Used plugs require increased voltage because electrode erosion has increased the gap width.

Spark plugs with good fouling characteristics will contribute to satisfactory performance by keeping the voltage available as high as possible. Spark plugs with favorable electrode-erosion characteristics will contribute to satisfactory performance by keeping the voltage required as low as possible.

The modern spark plug with built-in noninductive ceramically bonded resistor not only reduces ignition interference with radio, short wave communications, and television to acceptable levels, but also reduces electrode erosion to the point where wider gap settings and their attendant contributions to improved engine performance become practical.

Wide gap settings are capable of igniting lean or stratified mixtures which cannot be ignited by smaller settings. Therefore, under any condition of operation where the mixture at the spark-plug gap is lean or stratified, wide gaps will minimize the missing condition which would exist were plugs with smaller settings in use. Wide gap settings have this effect because the initial volume of mixture ignited has a reduced surface to volume ratio, and less spark energy in the form of heat is lost under these conditions to

the unburned mixture.

Heat range determinations on modern spark plugs are now much more precise than in past years. Practice at Auto-Lite is to rate plugs in terms of imep in a 17.6 cu in. supercharged single-cylinder engine operating on a fuel with an extrapolated rating of 150 octane. During these tests all variables of engine operation are maintained constant except engine power, which is increased in small increments by a means of increased airflow from a separately driven compressor. Preignition is indicated by a thermocouple within the engine cylinder.

Lead fouling characteristics of spark plugs are determined in a similar engine equipped with a means for measuring the spark plug shunt resistance to ground during operation. In this case, the engine is operated at very light loads with a heavily leaded fuel for a specified period of time. Following this a regular preignition test is run using the same fuel. The imep that a plug will obtain expressed as a percentage of its normal rating without the shunt resistance dropping to 1 megohm is taken as the measure of its fouling rating.

Caterpillar's Service Operations

Based on paper by

T. M. FAHNESTOCK

Caterpillar Tractor Co.

CATERPILLAR'S service department prepares printed material for both operator and mechanic, trains men, and serves as liaison between field and factory.

The service publications division prepares operator instruction books for major products. It also prints servicemen reference books showing engineering fits and limits, service wear limits, and assembly and disassembly procedures.

Factory representatives, field servicemen, and military personnel are trained by the service development division. It also develops special shop tools to simplify repairs.

The service engineering division reviews machine performance in the field and reports any indicated design or manufacturing changes. (Paper "Why a Service Department," was presented at SAE Central Illinois Section, Peoria, Nov. 21, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Airline Problems Challenge Engineers

Based on paper by

EDWARD H. BARKER

Parks College of Aeronautical Technology of St. Louis University

AERONAUTICAL engineers have wide opportunities in air transportation because: (1) passenger travel by air will continue to grow and revenue from air cargo will exceed the passenger revenue; and (2) the need for such engineers in the airlines is greater than has ever been properly met.

Airline engineering work consists of determining the most suitable type of aircraft among those available for the particular route system, modification of manufacturers' operating manuals to individual airline system regulations, determining the best cruising power and altitude for individual routes, solving problems of absorption of new aircraft types into a particular system—including necessary modifications of the original design, and host of other functions. Among these are the design, development, and modification of auxiliary equipment used in passenger handling, cargo loading, maintenance, and airport design and construction.

Applied to these problems, the airline engineer needs much the same qualities and knowledge as does the original design engineer, although the problems to which the latter applies his skills are different ones.

What Engineer Needs

Qualifications needed include the following:

1. A well grounded knowledge of the fundamental engineering subjects of maintenance, physics, drafting, and applied mechanics . . . also fundamental courses in electricity and advanced drafting.

2. Thorough knowledge of English, economics, industrial management, and business administration. Ability to express one's self and to understand business operations is of extreme importance.

3. Fundamental training in practical processes of sheet metal fabrication, machine shop practices, and other mechanical skills from point of view of production.

4. "Engineering depth perception" . . . good grounding in engineering fundamentals; sincere interest in this type of work; and an open eye toward limitations of production methods. . . . Power to recognize a problem and go to the base of it.

5. A better-than-average level of intelligence and a natural degree of versatility.

No field of engineering offers more challenge to versatility, or possesses the pressure and urgency of analytical thinking, or is more devoid of routine and specialization than engineering in the airline field. (Paper "Opportunities for Aernoautical Engineers in Air Transportation," was presented at SAE Annual Meeting, Detroit, Jan. 9, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Checklist on Placing Units for Field Tests

Based on paper by

FRANK A. GROOSS

Caterpillar Tractor Co.

IN the placement of experimental equipment for field testing, there are five questions to consider:

Question 1—How many units should be placed in the field?

Considerations—(a) Number required to give complete coverage. (b) Time element or test duration. (c) Nature of test. (d) Cost per test unit. (e) Field to be covered.

Question 2—Where should the units be placed?

Considerations—(a) Type of work to be done. (b) Hours and days of running time required. (c) Accessibility to facilities. (d) Climatic conditions.

Question 3—When should the units be placed?

Considerations—(a) Time of completion of laboratory tests. (b) Time needed to find suitable test locations. (c) Proper stage of project. (d) Period when proper weather conditions exist.

Question 4—With whom should the units be placed?

Considerations—(a) Through a cooperative distributor who understands placement problems, will cooperate with service helps, and is not prematurely enthusiastic about marketing possibilities. (b) With a reliable equipment user who is interested in the project and will supply adequate records, service, and work conditions.

Question 5—How long should the unit remain under test?

Considerations—(a) Total number of hours necessary for evaluation. (b) Calendar time necessary for evaluation. (c) Value of test under study. (d) Cost of test under study. (Paper "Choosing Proper Test Environment" was presented at SAE Central Illinois Section, Nov. 21, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

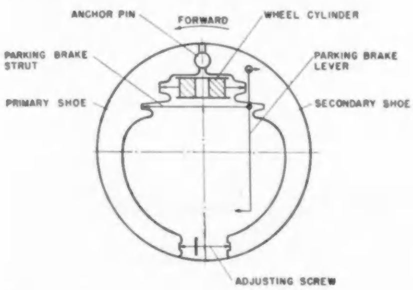
Three Types of Shoe Brakes

Based on paper by

CLARK R. LUPTON

Bendix Products Division
Bendix Aviation Corp.

1. Duo Servo Brake



This brake, commonly used in passenger cars, is generally made with a stamped steel brake support or backing plate. To it are attached the brake shoes, hydraulic wheel cylinder, anchor pin, adjusting screw, and parking brake actuating linkage (used only in rear brakes).

Hydraulic pressure in the wheel cylinder forces both shoes into contact with the brake drum. In counterclockwise drum rotation, the left shoe is the primary and the other the secondary.

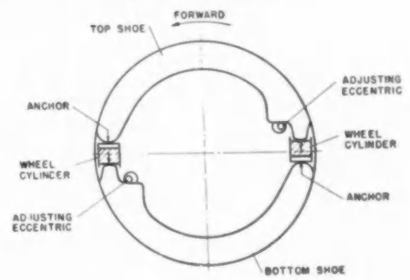
The primary shoe leaves the anchor pin because of the friction between the drum and brake lining, and anchors on the adjusting screw. This anchor load becomes the applying force on the secondary shoe. The secondary shoe is forced into the drum with a load much greater than that exerted by the wheel cylinder. The drum carries both shoes around, with the secondary shoe anchoring on the anchor pin immediately above the wheel cylinder.

With opposite drum rotation, the brake functions the same way; but the secondary shoe becomes the primary.

The name for this brake is derived from its functions. "Duo" represents the two directions of drum rotation, and "Servo" the action of one shoe on the other.

The cable pull on the lower end of the parking brake lever actuates the brake mechanically. The brake is adjusted by the screw between the lower ends of the shoes to reduce lining-to-drum clearance. The parking brake linkage remains in about the same released position throughout brake lining life. This is attractive from a service standpoint.

2. Twinplex Brake



The Twinplex type brake consists of a stamped-steel backing plate, to which are attached two identical brake shoes, two wheel cylinders, two adjusting eccentrics, shoe hold-down springs, and shoe return springs.

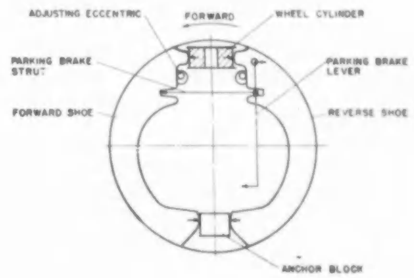
With hydraulic pressure built up in the brake cylinders, both shoes pivot about their anchors and contact the brake drum simultaneously. The shoes anchor on machined surfaces of the wheel cylinder castings. They return against the externally adjustable eccentrics.

The shoes are not anchored on pins secured in the backing plate. The rounded shoe ends anchor against flat surfaces, allowing the shoes to float and center themselves in the drum. This holds four advantages over the fixed anchor design: (1) better shoe centering in drum, particularly after initial adjustment, (2) slightly higher effectiveness, (3) less brake noise, and (4) more economical construction.

Work done by this brake is evenly divided between the two shoes. But for a given shoe thrust, the brake is more effective with forward drum rotation than with reverse. With forward rotation, tangential force imposed on each shoe by the drum adds to the wheel cylinder actuating force. Anchor loads are greater than with reverse drum rotation, where tangential loads work against applying loads.

When lining wear adjustment is needed, the adjusters are rotated as much as the lining clearance allows. The shoe-return springs maintain enough pressure on the adjusters at all times to prevent rotation during brake actuation.

3. Non Servo Brake



Hydraulic pressure in the one wheel cylinder forces both shoes into the brake drum. The block between the lower ends of the shoes takes the anchor loads.

With equal force from the wheel cylinder on each shoe, the forward shoe does more work with forward drum rotation. Tangential force on the forward shoe supplements the applying force to create a greater load on the anchor block. Tangential force on the rear shoe bucks the applying force.

With straight bore wheel cylinder and identical lining segments on each shoe, the forward shoe lining will wear faster. This wear differential can be reduced in three ways: (1) reducing the area of the lining segment on the rear shoe, (2) using dissimilar materials on the shoes, (3) using a step-bore wheel cylinder to get greater thrust on the reverse shoe than on the forward one.

Some vehicle makers prefer to put the forward shoe to work by using a step-bore wheel cylinder that exerts greater force on the forward shoe than on the reverse one. They feel this gets the most from the brake for given line pressure and fluid displacement.

For mechanical actuation, the cable pull on the lever's lower end forces the forward shoe into the drum by compression in the horizontal strut. Reaction on the pin at the lever's upper end forces the reverse shoe into the drum. This applies the brake against both forward and reverse drum rotation. Parking brake cables get slack with lining wear and need periodic adjustment. (Paper "The Versatile Shoe Brake," was presented at SAE National

Passenger Car, Body, and Production Meeting, Detroit, March 15, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Airlift Proved Value of Parallel Runways

Excerpts from paper by

COL. T. R. MILTON

Military Air Transport Service

THE ideal modern air transport airfield, to be capable of handling a steady stream of traffic, must have parallel runways.

If there are runways in more than two directions, they must come at least in pairs. If there are room and money or material enough to build three runways, then they should be parallel to give one spare for emergencies. Further, if the runways are in more than two directions, the direction of traffic should be changed only for major variations in wind direction and velocity, because a modern tricycle-gear transport in the hands of a capable pilot is capable of landing in crosswind components up to 35 knots at 90 deg.

This is one of the lessons learned from the Berlin airlift.

At the beginning of that operation we were faced with the problem of building a new runway at Tempelhof because the only existing runway was in a very bad state of repair. Because of the restricted airdrome area, we were forced to build the new runway parallel to the old one. This was done with the full knowledge that the prevailing winds would normally be 45 to 90 deg across and often of velocities approaching 30 or 35 knots. The length was something over 5000 ft, and the surface was pierced steel planking —treacherous material in wet weather.

We found that in spite of buildings on the final approach, a short runway with obstructions at either end, high winds, bad visibilities, and turbulence which tended to increase final approach and landing speed, we were able to operate with the 90-deg crosswind component of 30 knots with acceptable safety standards.

The traffic control problem was definitely simplified, and the approach pattern had only to be set up and marked for two landing directions, making a straight-in approach an actuality. Take-offs and landings with these parallel runways were greatly expedited.

This parallel runway system then became the pattern for all our airdromes. In no case did we have intersecting runways. We did, however, lay out wherever possible our runways into the prevailing wind, deviating from this only to the extent necessary to give good approaches. (Paper "Lessons Learned from the Berlin Airlift" was presented at SAE Washington Section, Nov. 15, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Suggests Aircraft Be Designed For at Least -80 F Operations

Excerpts from paper by

J. T. DYMENT

Trans-Canada Airlines

MANY problems are encountered in cold-weather operations. These problems arise, we feel, chiefly because of the existing standard deemed adequate for satisfactory cold-weather operation. The use of -65 F as a standard is not enough. Either a standard based on "wind chill" (a quantitative description of the relative severity of combinations of wind and low temperatures) must be used or a much lower temperature than normally encountered must be used to give the equivalent of a higher temperature with wind. We have felt that parts must operate satisfactorily in still air temperatures down to at least -80 F if they are to operate satisfactorily under high wind conditions at around -40 F.

Many of the manufacturers' personnel still do not appreciate the difficulties involved in servicing an airplane in the open at extremely low temperatures. If they appreciated the situation, there would by many changes in existing detail designs.

A tremendous amount of work is still required to develop materials that are satisfactory over the wide temperature range that they may encounter in service. The majority of this development work is required in the field of plastics and oils.

A vast amount of knowledge has been gained in cold-weather operations during the past few years. I feel that it would be to the benefit of all of us to interchange this information as much as possible by having papers prepared for the various meetings held at frequent intervals in this country. It will be found that every operator experiences certain conditions that others have not yet encountered. If we could get these experiences on paper, we would be better prepared for the future and could also ensure that when we purchase new aircraft in the future they would be more effectively designed to combat the conditions that will be encountered. (Paper, "Some Tricks in Cold-Weather Operations," was presented at the SAE Annual Meeting, Detroit, Jan. 9, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Knocking Measured By New Technique

Based on paper by

D. R. DEBOISBLANC

Phillips Petroleum Co.

THE definition of detonation in terms of the maximum differential rate of change of pressure in the disturbance has made possible the development of instrumentation for the actual quantitative measurement of detonation intensity.

Other present-day systems operate indirectly by measuring the resonant response of the cylinder to the pressure disturbance (rather than by indicating changes in the disturbance itself), and so, at best, are capable of giving merely a rough indication of the intensity of the knock.

The maximum differential rate of change of pressure is a better measure of detonation intensity than the indications of detonation given by the other systems because this quantity is more nearly independent of cylinder geometry and is more closely related to the elementary event than the resonant response of the cylinder gases. There are generally an infinite number of pulse shapes that will give a particular resonant response to the cylinder, which thus complicated the earlier methods. The space-time relations of the pressure pulse and its location in the cylinder determine the degree of excitation of the normal modes, and for each event the response is unique. It is for this reason that they have been made the basis of the author's system.

Actually, the detonation pulse is a complex wave that includes frequencies ranging from 0 to some upper limit

determined by the time interval in which the event takes place.

What the cylinder does is to respond selectivity to certain regions of this frequency spectrum. Even after the transient disturbance has subsided, the cylinder gases continue to vibrate for some time.

The new system of measuring detonation has many applications. For instance, it has been applied to the ASTM motor and the CFR research rating procedures,[1] where it gives a good signal-to-noise ratio and a high degree of reproducibility. In these cases the bouncing-pin mechanism is replaced by an electromagnetic pickup in the cylinder, which converts the pressure variations into voltage, and which in turn is fed to an instrument called the detonation meter.

The quantity actually measured by this system is the change in maximum differential rate of change of pressure from one fuel to another (one fuel generally being the reference fuel) at a given compression ratio.

Included in the instrumentation is a lowpass filter network, which passes waves of all frequencies up to a certain so-called cut-off frequency. (For example, 5000 cps is a typical cut-off frequency for unsupercharged engines.) This allows measurements to be made without interference from the cylinder resonances. Reasoning based on electrical transmission network theory shows that the new method also involves no loss of essential information and that the measurements can be made without interference from the cylinder resonances.

When a filter is used that is sharply tuned to some range in which the "characteristic" frequencies of the cylinder have a dominant energy band —as is done in some semiquantitative systems for evaluating detonation— there is a certain degree of uncertainty because of the variation in the resonant frequency of the cylinder modes, and of the degree to which these modes are excited, which makes the response difficult to interpret quantitatively. Systems using such filters are useful only when the rate of change in detonation intensity with engine conditions is great enough so that the precision of the tests is limited by other factors and a semiquantitative indication of detonation is adequate. (Paper, "Some Fundamental Aspects of the Measurement of Detonation," was presented at the SAE Annual Meeting, Detroit, Jan. 10, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

[1] See Oil & Gas Journal, Vol. 45, Nov. 9, 1946, pp. 57-59: "Electronic Detonation Meter for Motor Fuel Antiknock Rating," by D. R. deBoisblanc and H .M. Trimble.

Improved Lubricants For Railroad Diesels

Excerpts from paper by

E. F. H. PENNEKAMP, L. E. MOODY

Standard Oil Development Co.

AND

H. L. BAKER

Esso Standard Oil Co.

THE results of extensive field tests confirmed the value of conducting carefully controlled, full-scale field performance tests in the development of lubricants for railroad diesel service. Numerous attempts since the completion of this field program to correlate the results of laboratory engine tests with those of the field tests have been unsuccessful. To date, no adequate laboratory test for the evaluation of railroad diesel lubricants has been suggested.

Specific conclusions are as follows:

1. The only certain way to determine the performance of new lubricant compositions from the standpoint of engine deposits and effects on engine metals is the testing of the products in the actual diesel equipment using representative operating conditions. This will undoubtedly be more important in the future since further improvements in lubricants will be more difficult to attain. Thus, critical performance differences will be less pronounced and harder to evaluate.

2. In the formulation of railroad diesel oils a careful selection of base stock and detergent additive must be made to obtain optimum engine cleanliness and still maintain satisfactory freedom from corrosive tendencies toward critical engine parts such as the silver wristpin bushings used in electromotive equipment.

3. The addition of an effective nondetergent oxidation inhibitor to a base stock may result in lower viscosity increase and neutralization number values but, unlike the addition of detergent-inhibitor additives, the use of the straight inhibitor fails to reduce deposit formation in railroad diesel-engine service.

4. The condition of the used oil in railroad diesel engines does not give an adequate indication of engine deposit condition, since this factor is apparently more a reflection of the inherent characteristics of mineral oils and additives than of the performance of the lubricating oil in the engine. Thus, while it might be possible to determine a pattern of normal used oil condition for a given lubricant in a given service, this factor alone cannot be used to judge the engine condition. This, of course, does not eliminate the value of used oil inspections in following the operation of diesel engines, since used oil condition can be used for preventive maintenance, once the normal condition has been established. With this system of preventive maintenance, any wide variation in used oil condition can be used to indicate abnormal engine operation. Similarly, the oil drain period should be established individually for each railroad service, depending upon the condition of the diesel engines and the used oil. (Paper, "The Lubrication of Railroad Diesel Engines," was presented at the SAE National Fuels & Lubricants Meeting, St. Louis, Nov. 3, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Strain Gages Favored for Stress Analysis

Excerpts from paper by

H. W. FALL

Caterpillar Tractor Co.

EXPERIMENTAL stress analysis as practiced in industry today involves (1) determination of operating stresses in a part or assembly and (2) evaluation of the effect of these stresses. The stresses are determined from measurements of very minute deformations. The proper evaluation may be made of these stresses from data already available on a material or by fatigue tests when the occasion demands.

Strain gages are the method of measuring normal strain favored by many laboratories. They may be used for both static and dynamic strain measurements as well as in load-measuring devices or controlling devices. The gages are of simple construction, consisting of a grid of fine wire bonded to suitable backing material. This assembly, which is smaller than a 3¢ stamp, is cemented to the part to be stress analyzed. Gages may be purchased in different shapes and gage lengths varying from 1/16 to 1 in.

The electrical resistance of the gage increases for tensile strains and decreases for compressive strains. In order to measure the change of resistance, the gage is generally connected into a Wheatstone bridge circuit, and the variation in voltage between two locations in the circuit is measured. The voltage change in some cases is recorded on paper or film. From this voltage measurements, and a knowledge of the circuit, the strain may be determined and finally the

stress calculated.

Once we have determined the stress magnitude in a structure, we are confronted with the problem of deciding whether it is too high. The first consideration in making this decision is the type of load: Is it a problem in static loading, or is it a problem of repeated loading, that is fatigue? The maximum safe stress will be quite different in each of these cases. If the loading is static, the choice of a maximum working stress will be fairly simple. However the selection of a safe working stress for repeated loads is not so simple. Some of the considerations that should be made are: (1) the type of stress system, (2) the size of the part, (3) the stress range, (4) the hardness of the metal, and (5) the degree of stress concentration.

Very often it is necessary to evaluate the effect of various production processes on the fatigue strength of a part. Processes such as surface finishing, heat treating, and forming may greatly reduce the endurance limit.

When the interrelationship of all the factors influencing the fatigue life appears too complex to analyze theoretically, it is necessary to run full-scale fatigue tests on the part in question. In these tests, the specimens may be assemblies or only sections of a single part. In each case, however, the specimens should be selected from the production line in such a way that they are representative of the part that the customer receives. (Paper "Experimental Stress Analysis" was presented at SAE Central Illinois Section, Nov. 21, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)

How to Make Better Use Of Engine Test Facilities

Based on paper by

WILLIAM P. CROSS

Pratt & Whitney Aircraft

INCREASED productivity of aircraft engine test cells will come from speeding up each of the five engine test phases: (1) mounting and dismounting, (2) running of test, (3) repairing engines in cell, (4) waiting and inspection, and (5) cell maintenance.

Complete engine preparation before delivery to test cell and quick mounting facilities will minimize mount and dismount time. At the preparation line, stands should hold engines in flight position and be raised, lowered, or rotated by push-button controls. See Fig. 1. Here test fittings, exhaust stacks, test oil lines, thermocouples, wiring, propeller, and other similar components are installed before, and removed after, the test.

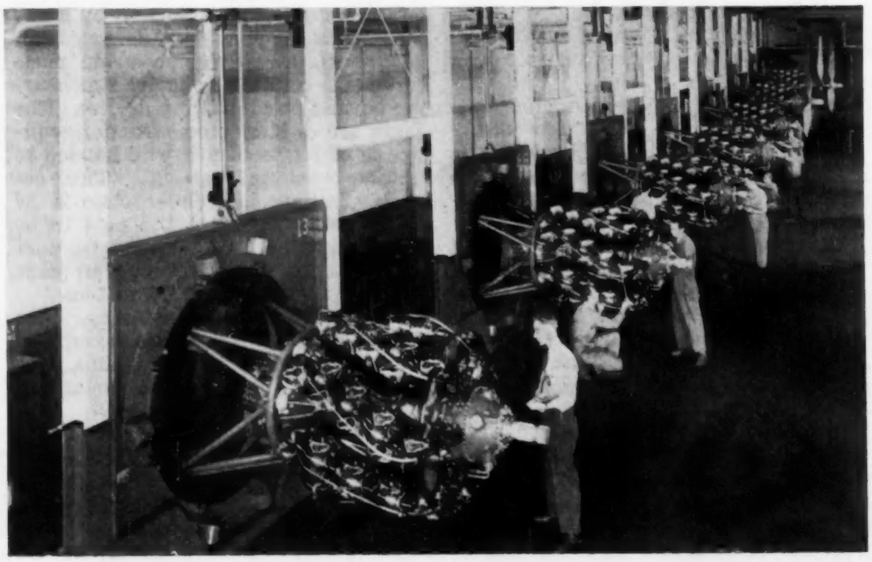


Fig. 1—Pratt & Whitney helps speed its test cell operations by using these preparation stands, equipped with push-button controls for raising, lowering, and rotating the engine

Use of the following equipment will facilitate quick mounting:

a. An overhead electrified monorail system to carry the engine from preparation line to test cell.

b. Test stands designed for testing either tractor or pusher engines.

c. Toggle bolts for securing the engine.

d. Quick connectors for gage, hydraulic, fuel, and oil lines.

e. Retractable work platforms for easy access to all parts of engine and propeller.

f. Cooling ducts which can be quickly swung into place.

Mounting and dismounting a Wasp Major engine was reduced from an 8-hr to a 75-min operation.

Incorporating new and improved equipment and instrumentation helps reduce running time. Audible and visible warning devices are invaluable in case of dangers such as oil loss or oil pressure drop. The engine can be stopped before damage is done. Typical instrumentation improvement is the flowrator for measuring oil flow. It eliminates stop-watch timing and computing of oil routed to a separate tank on scales by giving a direct reading.

Preventive measures will keep engine repairs to a bare minimum. For example, checking sub-assemblies on the assembled engine with hot oil under pressure will uncover leakage and restricted oil passages. Pre-oiling the engine, by driving it with external power splined to the propeller shaft and allowing the pumps to take oil from a supply tank, does two things. First it prevents damage due to lack of lubrication when starting the engine. Second, gage checks made insure proper pressures at all critical points.

Much waiting time can be eliminated by careful scheduling. As one engine completes the test, another should be ready to take its place. Operating on a three-shift basis also saves considerable test time. Otherwise, the engine is shut down and must be prepared for the night. This loses between 20 and 45 min at the end of the shift. Test phases that cannot be finished before the end of the day have to be held over to the next morning. The engine must be rechecked and warmed up, losing an additional 15 min to 1 hr.

Complete cell overhaul after every 500 hr use minimizes time lost for maintenance. It virtually eliminates lost time due to equipment failure. Periodic overhaul also saves maintenance time over a continual procedure, such as a partial overhaul on a one-shift-per-week schedule.

Main factor in effective test facility use is personnel. Test operator efficiency is essential to test cell efficiency. Supervision must see that every man is on the alert for ways to improve his efficiency. Many changes recommended by supervisors reduce test cell

te. (Discussion "Maximum Usage of Test Facilities," was presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 7, 1949, as part of Producibility Panel on "Optimum Engine Producibility." Complete panel is available in multilithographed form from SAE Special Publications Department. Price: 75¢ to members, $1.50 to nonmembers.)

Porous Walls Used in Cascade Tunnels

Based on paper by

J. R. ERWIN and J. C. EMERY

Langley Aeronautical Laboratory, NACA

(This paper was printed in full in SAE Quarterly Transactions, April, 1950.)

NACA researchers at Langley Aeronautical Laboratory have found that substituting porous side walls for the usual solid walls of cascade airfoil test rigs and drawing off the boundary layer of the airflow results in a much closer approach to two-dimensional flow. Data obtained this way are more reliable and, therefore, more useful for designing axial-flow compressors.

The researchers reasoned that with conventional cascade tunnels, interaction and interference of the side-wall and test-airfoil-surface boundary layers produces a large low-energy region at the exit from the cascade, this wake acts as a restriction on the flow, higher average exit velocities result, and the flow is not two-dimensional. They believed that if the side-wall boundary layers could be removed continuously through the side walls, two-dimensional flow might be established.

Canvas Too Rough

To investigate this hypothesis, side walls of two cascade tunnels were replaced with frames supporting a perforated metal sheet to which porous materials could be attached. First results with heavy canvas as the porous material were encouraging but indicated that the roughness of the material affected the quantity of airflow that had to be drawn off to establish two-dimensional conditions. So various porous materials were tried.

Data obtained with porous-wall tunnels proved that this arrangement can satisfy the criteria of two-dimensional flow. For example, good agreement was achieved with the porous-wall cascades between normal force coefficients calculated from momentum and pressure changes and those obtained by integration of the measured pressure distributions — an agreement not obtained with solid-wall cascades.

With continuous boundary layer removal, cascades of aspect ratios of 1 and 4 produced turning angle of attack curves for NACA 65-(12)10 airfoils very similar to curves from two test blowers, when the pressure rise associated with the measured turning was established. (Paper "New Approach to Axial Compressor Cascade Testing Technique" was presented at SAE National Aeronautic Meeting, Los Angeles, Nov. 6, 1949. This paper is available in full in photolithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Future Engineers Will Have Plenty to Do

Excerpts from paper by

HARRY STANTON

Boston Globe

THE apparently insatiable desire of Joe Public to hurry to his destination so he can sit down and rest his back may well create a sustained demand for faster and more powerful cars in the years to come. As a matter of fact, practically everyone in the industry already is working toward this type of design. We haven't arrived at the all-plastic blister top yet, but windshields and windows grow bigger with each succeeding model. Rear engines haven't arrived, but there is plenty of talk about them. Front passenger compartments are edging toward the front of the car, bit by bit.

The engineering opportunities created by a development of this nature are nothing short of staggering. Perhaps the most urgent problem of all is that of safety. If we are going to have cars like this we will have to make everything connected with them as nearly foolproof as possible, and that is going to take a tremendous amount of engineering thinking. One of the things we must do is to engineer our highways so we will have some place to drive such cars.

The big job ahead of us is to engineer the cars, the highways, and the traffic control mechanisms so they will eliminate the opportunities for accidents, or at least reduce them materially.

Here are some questions for everyone to think about: What kind of brakes are we going to have on that sleek and racy new model?

What sort of warning signals are we going to have to inform the fellow following us that we propose to stop?

What are we going to do about headlights for night driving?

Just think ahead a little and start figuring out what we are going to have to do when we are driving those 100-mph jet-propelled monsters?

In addition to the problems brought on by speed alone there are a lot of other things to think about. How are we going to keep people in their own lanes?

Icy roads are a perennial problem.

Maybe some genius can devise a way to inflate the tires and maintain constant pressure, with enough surplus to take care of any ordinary hole that may occur at high speed.

How about some kind of electronic device that will flash a red warning light and sound an alarm when a car rushes toward a big trailer-truck stalled on the highway with fuse trouble in the interval between the time the lights go out and the time when the driver can stop his machine and set up a flare?

Should we have a block system on our superduper highways that will prevent accidents by automatically maintaining a safe distance between cars—like they do it on the railroads?

All of these crazy notions are suggestions of things that need to be done, even now, and only your own fertile imaginations can fill in the gaps that will show themselves in the future. (Paper, "Looking over the Horizon of the Automotive Field," was presented at a meeting of the New England Section of the SAE, Boston, Nov. 1, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Cast Iron Leading Brake Drum Material

Based on paper by

FRED J. WALLS

International Nickel Co., Inc.

(This paper will be printed in full in SAE Quarterly Transactions.)

HIGH-CARBON cast irons make better brake drum surfaces than any other known alloy because of their resistance to heat checking and high compressive strength.

The higher the graphitic carbon, the more resistant is the iron to heat checking. Probably high graphitic carbon content keeps modulus of elasticity low so that thermal stresses are lower. But more important, perhaps, the graphite behaves like a liquid, more readily distributing the stresses. This

also could account for cast iron's high compressive strength.

Fact that cast iron is three to five times as strong in compression as in tension may account for some of its merits as a brake drum material. (Other materials have about the same compressive and tensile strengths.) The weaker irons have the higher ratio; an iron with 20,000 psi in tension will exhibit a compressive strength of about 100,000 psi.

High-carbon cast irons also decrease diameter-shrinking tendencies, experienced with medium carbon steels in aircraft drums before 1940. This may be due to the high compressive strength. Bimetallic drums, of the centrifused type, need a steel backing about three times the thickness of cast iron to minimize diameter shrinkage.

Modulus of cast iron varies inversely as the total carbon content and is somewhat independent of its tensile strength. This makes possible use of high total carbon irons to meet low modulus requirements and at the same time to approach required strength in a single material.

The paper also discusses the braking heat dissipation problem, general brake drum requirements, and metallurgical and physical properties of various materials. (Paper "Brake Drum Materials," was presented at SAE Annual Meeting, Detroit, Jan. 13, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Peacetime Subcontracting To Help in War Emergency

Based on paper by

K. N. BUSH

Aircraft Gas Turbine Division, General Electric Co.

GENERAL Electric's use of 200 subcontractors, in its J-47 aircraft gas turbine program at its Lockland, Ohio plant, will ease rapid expansion in case of national emergency.

While J-47 peacetime requirements easily could have been met in the original plant at Lynn, Mass., this type of operation makes it tougher to meet wartime needs. Keeping production and know-how within one plant seriously handicaps all-out war effort. Aircraft industry facilities developed during World War II were in danger of withering on the vine. There was also the hazard of losing the small nucleus of trained personnel needed to build up the industry to a wartime potential.

To circumvent these dangers to national security, the U. S. Air Forces has established the Lockland operations. General Electric assembles and tests the J-47 engines in the Lockland plant. Subcontractors — some from the aircraft industry and others from associated industries—furnish all component parts.

Selection of subcontractors was based on these factors:

1. Facilities required to do the particular job.
2. Facilities available in the subcontractor's plant.
3. Subcontractor's previous experience and performance record on similar parts.
4. Subcontractor's quoted price.

At least two, and preferably three, sources of supply were established for each item.

The subcontractor assumes full responsibility for procurement of his materials and production tools, such as jigs and fixtures. For economy in tools and patterns, General Electric coordinates procurement of certain major items. Many suppliers gained first-hand knowledge of the parts they were to make by studying operations at the GE Lynn plant, where the identical engine is being produced.

Of the 200 subcontractors throughout the country contributing to this program, 40 supply the 15 major components; 50 others supply these 40 with basic parts; 50 more supply accessory items such as fuel regulators; and more than 60 suppliers furnish fittings, nuts, and bolts.

Subcontractor performance to date has helped maintain the original engine schedule. Day-by-day price reductions are being made. But more important, by the Lockland philosophy, each subcontractor can expand so that substantially increased capacity will be available if ever needed.

Though still in its infant stages, the Lockland operation has proved itself workable and practical. (Discussion "Maximum Use of Subcontracting—Philosophy of Lockland Operations," was presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 7, 1949, as part of Producibility Panel "Optimum Engine Producibility." Complete panel is available in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)

Diesel Compared With Gasoline Engine

Based on paper by

FRED B. LAUTZENHISER

International Harvester Co

DIESELS surpass gasoline engines for trucks on seven counts, but fall back on twelve. However, each has its place in truck service, depending on the economics of the operation.

The diesel's advantages are:

1. Fuel Economy. Present-day diesel are at least 20% more economical than gasoline engines on a pounds-per-brake-horsepower-hour basis. Diesel fuel also costs appreciably less than gasoline.
2. Fuel Variety. The diesel can burn a wider variety of fuels than the equivalent gasoline powerplant.
3. Efficiency. It converts into useful work more heat energy in the fuel and ranks as the most efficient international combustion engine on this score.
4. Fire Hazard. Faulty maintenance and careless operation can make a gasoline-powered truck hazardous because of the fuel's high flammability. Diesel fuel is not highly flammable.
5. Service Troubles. Diesels eliminate the two biggest sources of maintenance troubles—the ignition system and the carburetor of gasoline engines.
6. Better Distribution. Because the diesel meters the fuel in equal amounts to each cylinder, the fuel mixture is better distributed and burns more uniformly.
7. Longer Expansion Period. Fuel oil burns slower in the diesel combustion chamber so that the expansion period is longer. This is why the diesel provides greater lugging ability than the gasoline engine.

Disadvantages of the diesel are:

1. Higher Initial Cost. The diesel is inherently more costly because of its precision-built injection system, greater weight per brake horsepower, and the relatively small volume production.
2. Greater Weight. The diesel is made heavy to resist the stresses from high compression and explosion pressures. This limits rpm and makes for higher weight per horsepower.
3. More Noise. Some diesels operate rough and noisy, largely because of inexperienced designing in the automotive field.
4. Odor. Diesel odors are objectionable in the city. But improving combustion may help overcome this problem.
5. More Smoke. Smoky diesel exhaust stems from incomplete combustion and inefficient driver handling. Preventing driver tampering with fuel adjustment and improving combustion

should help alleviate the smoke complaint.

6. Engine Size. The diesel occupies more space for a given power output. It limits load-carrying space in states enforcing overall lengths.

7. Higher Service and Parts Costs. Fewer skilled mechanics are familiar with the diesel, so that good diesel men command higher wages. Prices for diesel replacement parts will remain comparatively higher until produced in larger quantities.

8. Difficult Starting. The higher compression pressure makes the diesel tougher to start. Most use 12 to 24-v batteries in high-torque starting motors. Subzero temperatures add to these troubles.

9. More Vibration. The diesel vibrates considerably more than the gasoline engine because of high compression and explosion pressures and heavier reciprocating parts.

10. Lubrication a Problem. Combustion products are driven past the piston rings and contaminate the oil.

11. Frequent Fuel-Filter Cleaning. Dirty fuel causes closely fitted parts in fuel injection pump, nozzles, and valves to stick, and wears and scores plungers.

12. Less Speed Flexibility. Because of heavier reciprocating parts, the diesel doesn't respond to the throttle as quickly as the gasoline engine.

Comparing the two types on operating costs requires that both: (a) operate under the same conditions, (b) handle the same gross weights, (c) operate over the same roads, (d) and be driven by the same driver. To see how operating costs compare, here are paralleling costs for several cases:

One operator handled 80,000-lb gross weights on comparatively short hauls in Ohio. Each truck was operated about 200 miles per day. Based on roughly 400,000 miles to date, this fleet man's cost records show:

	Miles per Gallon	Fuel Cost per Mile	Total Cost per Mile
Diesel	5.89	1.73¢	10.6¢
Gasoline	3.36	3.70¢	11.2¢

The same equipment was operated in the same general locality, but with gross weights of 72,000 lb, and across country on long hauls of about 250 miles per day. The costs in this case after 450,000 miles, were:

	Miles per Gallon	Fuel Cost per Mile	Total Cost per Mile
Diesel	5.97	1.79¢	9.9¢
Gasoline	3.98	3.71¢	10.5¢

In another case, six-wheel trucks without trailers were operated in a midwestern state. They handled 50,000-lb gross weights, running about 70 miles per day on short hauls and under local traffic conditions. After 31,000 and 133,000 miles with the diesel and gasoline-powered vehicles, respectively, costs were:

	Miles per Gallon	Fuel Cost per Mile	Total Cost per Mile
Diesel	4.92	1.73¢	15.2¢
Gasoline	4.87	2.64¢	7.8¢

These examples demonstrate that costs per mile gradually decrease for both types as haul length and total mileage operated increase. But the gasoline-powered vehicle's operating costs are half that of the diesel's for lower gross weights, shorter hauls, and much less total mileage.

These figures do not include depreciation, drivers' wages, and insurance. Including depreciation would increase diesel costs much more rapidly because of the greater initial investment in diesels. Fuels prices ranged from 12½ to 14¾¢ per gal for gasoline and from 8½ to 10¾¢ per gal for diesel fuel. (Paper "A Nontechnical Discussion of Diesel Versus Gasoline Powerplants in Motor Trucks," was presented SAE Salt Lake Group, Dec. 5, 1949; SAE Northwest Section, Seattle, Dec. 9, 1949; SAE British Columbia Section, Vancouver, Dec. 12, 1949; SAE Oregon Section, Oregon, Dec. 14, 1949; and SAE Spokane-Intermountain Section, Spokane, Dec. 16, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Prices: 25¢ to members, 50¢ to nonmembers.)

Railroad Men Learn More About Diesels

Based on paper by

STANLEY E. LODGE

Locomotive Division
American Locomotive Co.

AMERICAN Locomotive Co.'s four-day instruction course helps train railroad personnel in maintenance and operation of diesel-electric locomotives.

First morning of the course consists of a description of the 1500-hp, 12-cyl and 2000-hp, 16-cyl Alco diesel engines. The trainees then assemble one bank of cylinders, the generator, and the free end of the engine, on a dismantled engine. Next day they are told about the rest of the parts they will install that day, which include the lube oil and water pump drive assemblies, turbosupercharger, timing gear, pistons, piston pins, and connecting rods.

The third day is devoted to detailed instruction on parts such as camshaft, cylinder heads, fuel injection system, and governor tachometer generator. On the fourth day the trainees dismantle the engine.

The railroads feel such instruction permits them to make the transition from steam to diesels with their present personnel, without turning to the outside for the needed skills. (Paper "Diesel Engine Maintenance," was presented at SAE Mohawk-Hudson Group, Schenectady, Jan. 18, 1950. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Sodium Sulfite Removes Aldehydes from Exhaust

From paper by

M. A. ELLIOTT and R. F. DAVIS

U. S. Bureau of Mines

(This paper will be printed in full in SAE Quarterly Transactions.)

EXPERIMENTS conducted by the Bureau of Mines show that substantially all the aldehydes can be removed from diesel exhaust by scrubbing with an inhibited aqueous solution of sodium sulfite.

Experience indicated that there is some correlation between concentration of aldehydes and the odorous and irritating character of diesel exhaust gas. So researchers sought a way to get rid of the aldehydes, especially for diesels used underground or in confined spaces.

Scrubbing with water proved impractical in trials because removal of aldehydes decreases rapidly with increasing concentration of dissolved aldehydes, particularly at elevated temperatures. But laboratory studies suggested that aqueous solutions of sodium sulfite might be better.

A scrubbing solution containing 10% by weight sodium sulfite and 0.5% by weight hydroquinone was compounded. (The hydroquinone serves to retard oxidation of the sodium sulfite by the residual oxygen in the diesel exhaust gas.) Exhaust from a four-stroke-cycle, 4-cyl diesel was scrubbed with the solution in a bubbling-type scrubber.

The scrubber held 10 gal of solution, and included a baffle plate and a cy-

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JAMES C. ZEDER has been made Director of Engineering and Research, Chrysler Corp., Chrysler President **K. T. KELLER** has announced. In his new position, Zeder will report to **F. M. ZEDER,** Vice President and Vice-Chairman of the Board of Chrysler, SAE President this year, J. C. Zeder had been chairman of the Chrysler Engineering Board since May, 1946. He first joined Chrysler Corp. when it was organized in 1925.

ELBERT E. HUSTED, President of Titeflex, Inc., was elected president by the Board of Directors of the Newark Chamber of Commerce. Husted served successively as second vice-president and first vice-president and as a member of the Chamber's City Affairs Committee. President of Titeflex since 1942, he is a veteran of overseas service in World War I, formerly holding reserve rank of lieutenant-colonel. He was an SAE councilor in 1948-49, and is a past-chairman of SAE Metropolitan Section.

CHARLES S. DAVIS has been elected to the newly created office of Chairman of the Board of Borg-Warner Corp. Davis, one of the founders of Borg-Warner in May, 1928, served as Chairman of the Board during the first year and has been president ever since then. For many years he was President of the Warner Gear Co., one of the four automotive parts companies that joined to form Borg-Warner two decades ago.

OTTO E. KIRCHNER, director of engineering at American Airlines' Tulsa Maintenance Base, has been appointed director of operational engineering and moved to New York to assume his new duties on April 1.

The promotion was announced by **M. G. BEARD,** who is serving as head of the airline's Engineering department in the absence of Vice-President **WILLIAM LITTLEWOOD.** Kirchner will serve as coordinator of American's aircraft operating and performance problems in relationship with governmental agencies. A graduate of the University of Alabama in electrical engineering and of Massachusetts Institute of Technology in aeronautical engineering, Kirchner entered the company in 1928 at Dallas as division engineer in charge of maintenance. He became chief engineer at Chicago in 1939 and was made director of aircraft engineering in 1943. After heading the research division of the department for two years, he moved to Tulsa to head engineering activity at the company's maintenance base in 1947.

He is chairman of SAE Committee S-1, Aeronautical Drafting Manual.

About

VINCENT ELLIS is no longer associated with Lear Inc., Grand Rapids, Mich. Ellis has rejoined Lord Mfg. Co. and has just taken charge of their New York field office as manager.

SAM TOUR, chairman of the board of Sam Tour & Co., Inc., of New York City; President of The American Standards Testing Bureau, Inc., of the Forty Four Trinity Place Corp. and of Graphitized Alloys Corp. also of New York City has just been elected Chairman of the Inter-Society Corrosion Committee of the National Association of Corrosion Engineers. He began his corrosion studies during World War I while employed by the Ordnance Department of the U. S. Army, and has been a member of the National Association of Corrosion Engineers for several years.

T. A. BOYD, who was one of the discoverers of the anti-knock characteristics of tetraethyl lead was guest speaker at the Metal Powder Show luncheon, April 26, Book-Cadillac Hotel, Detroit, Mich. The luncheon concluded a two-day annual meeting devoted to the metal powder industry. Mr. Boyd's address was entitled "Solomon's House."

OTTO W. HARRAH recently became associated with the Standard Oil Co. of Calif., Salt Lake City, Utah as a fuel and lubricant engineer.

WILLIAM T. DECAPUA is no longer connected with Beaver Metropolitan Coaches, Inc., Beaver Falls, Pa. He is now associated with the Marmon-Herrington Co., Inc., Indianapolis, Ind.

JOHN LYON COLLYER, who has been president of the B. F. Goodrich Co. since Nov., 1939, has been named chairman of the board. Collyer will continue as both chairman and president. He is a graduate of Cornell and has been associated with the rubber industry since 1923.

J. EDWARD C. ANDERSON has joined the Pesco Products Division of Borg-Warner Corp., Bedford, Ohio as a project engineer. He had a similar position prior to this with the Parker Appliance Co., Cleveland, Ohio.

Members

A. P. EMMERT becomes a vice-president of Borg-Warner, at the same time continuing to hold his present position as president of the corporation's Warner Gear Division.

A. T. COLWELL, vice-president of Thompson Products, Inc., and a past-president of the Society, has been appointed a director of Jack & Heintz Precision Industries, Inc.

WALLACE C. MANVILLE has been employed by A. Schrader's Son as resale representative for their Denver territory. Mr. Manville was with U. S. Rubber Co. for many years in various sales capacities. After leaving U. S. Rubber, he operated his own service station and retreading shop in San Diego, Calif.

ROBERT W. STEWART, a recent graduate from Ohio University, is now employed by the Ohio Oil Co., Orange, Texas in the production department.

WILLIAM E. MORRIS has joined the Petroleum Laboratories of E. I. du Pont de Nemours & Co., Inc., at Deepwater, N. J., to study the performance of leaded gasolines in automobile engines. He was formerly a research engineer at the Standard Oil Development Co.

WALTER S. HOWARD has been appointed sales engineer for automotive castings at the Lake City Malleable Co. Howard was formerly with White Motor Co. He has been engaged in a wide variety of efforts in connection with automotive engineering for many years and has participated in activities of the Society on committees and as chairman of the Cleveland section (1933-1934).

R. S. SADDORIS is general chairman of the American Society For Quality Control, which held its convention in Milwaukee on June 1 and 2.

LEONARD E. MILES has become sales engineer with the Butler Mfg. Co., Richmond, Calif. He was formerly with the American Overseas Petroleum Co., San Francisco, Calif.

GEORGE I. URSAKI is now associated with Henry Power Tools, Ltd., London, Canada, in the capacity of sales manager. He was previously employed with Sommerville, Ltd. as sales promotion manager.

PETER G. WARE, formerly chief technical assistant in the research division of Leyland Motors Ltd., Leyland, Lancs., England, is now personal assistant to the general manager at C.A.V. Ltd., London.

LUDWIG A. GRIBLER, JR., is now connected with Saginaw Steering Gear Division of General Motors Corp. as designer - product engineering. He was previously employed by the Continental Aviation and Engineering Corp. as engineer in the research division.

A. W. LINES, a director of Sealed Power Corp. and its Canadian affiliate since 1941, and also sales manager of the company's piston and sleeve division, has resigned effective April 15. He has no definite plans at present but will devote his time to other business interests.

WILLIAM T. BEAN, JR. has been appointed director of Industrial Electronics, Inc., a new Technical Service Center, Detroit, Mich. Bean, internationally known authority on experimental stress analysis, was previously in charge of the stress analysis laboratory of the research division of Continental Motors, and has been much in demand for the past year as a lecturer and consultant on instrumentation and application of Stresscoat and Strain Gages.

G. HAROLD OSBORNE has been appointed general manager of sales for the Kendall Refining Co., Bradford, Pa. He started his association with Kendall in 1933 as a refinery employee in the canning and shipping department, and since then has served the company in various capacities. In April, 1945, Osborne was promoted to manager of lubricating oil sales, serving in this capacity until his recent appointment. In his new position, he will be in charge of all phases of the marketing of Kendall's motor fuels and lubricants.

HARRY E. CHESEBROUGH has been appointed assistant chief body engineer in charge of the administrative functions of the car body sections in the engineering division of the Chrysler Corp., Highland Park, Mich. Following graduation from the Engineering College of the University of Michigan, and from the Chrysler Institute of Engineering, he served in Central Engineering as a project engineer and as a supervisor. During the past year and until this present appointment he has been chief engineer for the Dodge Car Division.

SEYMOUR J. CHENEY is now associated with the Warner Gear Division of the Borg-Warner Corp. as resident engineer at Detroit. He was previously research engineer for the Morse Chain Division of Borg-Warner.

SAE Fathers and Sons . . . .

JOHN D. DEBBINK of Chevrolet-Bay City Division of GMC, left, with his father, **HENRY L. DEBBINK**, superintendent of gasoline vehicles, Milwaukee Electric Railway & Transport Co. The elder Debbink is a past-chairman of SAE Milwaukee Section and his son was chairman of the SAE Student Branch at the University of Wisconsin. Their third generation SAE man, David is in the center.

If any SAE reader knows of SAE Father-and-Son combinations, both of whom are members of the Society, your editors would appreciate hearing from you.

We will write for photographs. Informal pictures of such combinations are preferred to individual formal portraits.

Your cooperation will be deeply appreciated—we don't want to miss any SAE grouping.

HERMAN L. HARMS, engineer manager of the Co-op Tractor Production Plant, Saint Paul, Minn., with his son, **GORDON E. HARMS**, an enrolled student at the University of Minnesota.

WINDSOR L. SHERMAN, formerly a graduate student at Brown University, is now employed by the National Advisory Committee for Aeronautics, Langley Air Force Base, Va. as an aeronautical research scientist.

ROBERT O. ZEIGLER, a graduate from Cal-Aero Technical Institute, is now with the Owens-Illinois Glass Co., Toledo, Ohio as a detail designer.

J. ARNOLD McCOY, formerly a farm machinery designer for the Lavers Engineering Co., Chicago, Ill., is now employed by Fairbanks, Morse & Co., Beloit, Wis. as a designer in diesel engine development.

ROBERT BRUCE UNDERWOOD is now mechanical engineer with Fairbanks, Morse & Co., Beloit, Wis. Prior to this, he held a similar position with the same company in Three Rivers, Mich.

LESLIE TYRUS COOPER, formerly a student at Tri-State College, is now employed by Charles F. Bamford, Portland, Ore. as an engineer.

DONALD E. ROGERS is now connected with Automaco, Inc., Birmingham, Mich. in the capacity of general manager and purchasing agent. Previously, he was an experimental student engineer with General Motors Corp., diesel engine division, Detroit, Mich.

NICHOLAS J. RAKAS, National Automotive Fibres, Inc., Detroit, Mich., has been elected to serve as one of the directors of The Society of The Plastics Industry, Inc.

FRED J. GERLING, formerly a special equipment engineer with the General American Aerocoach Co., East Chicago, Ind., is now employed in the Tractor Engineering Department of the Ford Motor Co.

KARL G. AHLEN, chief engineer in the hydraulic department of the Ljungstrom Steam Turbine Co., Stockholm, Sweden, stopped at SAE headquarters recently on his annual visit to New York.

EARL R. PIERCE is now a mechanical engineer—central engineering power development at General Motors Corp., Detroit, Mich. He was formerly in Melbourne, Australia as a transmission engineer for General Motors Overseas Operations.

DAVID HAYS LACHENBRUCH, a recent graduate of Parks College of Aeronautical Technology, East St. Louis, Ill., is now employed by Benoix International, New York as an aviation sales correspondent.

GEORGE VAUGHAN WARLOW, formerly sales manager—Toronto Branch of A. Schrader's Son, is now employed by the Lemery Distributors, Toronto, Ont. as manager.

R. DIXON SPEAS on June 5 became U. S. representative of A. V. Roe Canada, Ltd., producers of the AVRO Jetliner. With headquarters in New York, he will be engaged in sales engineering on turbo jet and turbo prop applications, particularly to air transports. He will be active in the process of certification of the Jetliner in U. S. and also will participate in the development work at Toronto. To join A. V. Roe, Speas leaves American Airlines, with which he has been associated in engineering capacities for a number of years. He is a past-chairman of SAE Metropolitan Section, has been active in development of many SAE meetings and technical projects, and is currently a member of the Air Transport Activity Meetings Committee.

FRANK O. TALLMAN, who is foreman of the engine and lubricants section of the Armour Research Foundation, Chicago, Ill., has general supervision of engine and lubricant oil testing. Prior to this, he was laboratory and instrument technician at Armour.

FRED C. HALL, formerly general manager of the California division and director of sales for U. S. of the American Coach & Body Co., Cleveland, Ohio, is now owner and sole proprietor of the Fred C. Hall Co., Oakland, Calif. The company will represent various companies in all phases of customer relations in seven western states.

WAYNE SIMON is now a junior engineer with the American Gas Machine Co., Albert Lea, Minn.

J. E. LACKNER, formerly chief lubrication engineer with The Texas Co., Seattle, Wash., is now supervising engineer for the same company in San Francisco, Calif.

WILLIAM M. CARPENTER is now a designing engineer for the Reeves Pulley Co., Columbus, Ind. Prior to this, he held the position of designer and layout man for the Hercules Motors Corp., Canton, Ohio.

CARL A. ANDERSON is now connected with the aero division of the Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

JOHN M. HEIMAN is now associated with the Aerojet Enginering Corp., Azusa, Calif. as a project planner.

ELLIOT SCHILLER is at present employed at the Glenn L. Martin Co., Baltimore, Md. in the capacity of propulsion engineer. Prior to this, he was with the Wright Aeronautical Corp., Wood-Ridge, N. J. in the capacity of senior test engineer.

H. G. ENGLISH (left) and **V. J. JANDASEK**, formerly with Borg-Warner Corp., have joined Ford Motor Co., Dearborn, Mich., as assistants to the research engineer. Both engineers have been active in developing Ford's new torque-converter type automatic transmission, to be introduced on Ford and Mercury cars later this year.

ENGLISH

JANDASEK

ROBERT E. ALLEN, vice-president of the company formerly known as Plastic and Rubber Products Co., writes that the name of the organization has been changed to Precision Rubber Products Corp. "The new name," he says, "more accurately describes what we are doing—producing precision-built "O" Rings from rubber-like elastomers."

MARK C. NICHOLSON, formerly a dynamometer operator with the Tucker Corp., Chicago, Ill., is now conducting his own farm implement business in Cabery, Ill.

CHET D. HIRSCH is now with the Ordnance Department of the U. S. Army at Ft. Sheridan, Ill. Previous to this, he was an operation officer at the Lincoln Ordnance Depot, Springfield, Ill.

ERNEST G. LeMAY, JR. is now connected with NEPA Division of Fairchild Engine and Airplane Corp., as a senior powerplant engineer. Prior to this, he was a project engineer with the propeller division, rocket department of Curtiss Wright Corp., Caldwell, N. J.

EUGENE S. MICHALCZYK of American Airlines, Inc., has been transferred from the position of senior mechanic, Line Maintenance, Cleveland, Ohio to the position of senior mechanic, Line Maintenance, Chicago, Ill.

JOSEPH D. GARRETT, formerly an experimental project engineer with Kaiser-Frazer Corp., Willow Run, Mich., has become a staff development engineer with Thompson Products, Inc., Cleveland, Ohio.

PHILIP MORRISON is employed by the Glenn L. Martin Co., Middle River, Md. as a junior engineering draftsman.

BERNARD J. KAPPLER, formerly a powerplant engineer with Pan American Airways, has joined the Trans World Airline, La Guardia Field, N. Y. as a flight engineer.

FRANCIS M. BALDWIN, JR. is now an engineer in charge at the Moye W. Stephens Co., Pomona, Calif. He graduated from University of Southern California last June.

HAROLD A. YOUNG, a recent graduate of the University of Maine, is now an observer in the process control department of Carnegie-Illinois Steel Corp., Chicago, Ill.

MICHAEL T. GACIOCH has become assistant to the chief engineer at the Oneida Heater Co., Oneida, N. Y. He was recently graduated from Rensselaer Polytechnic Institute.

WALTER H. CANFIELD, JR., who recently graduated from Indiana Technical College, has become a specification engineer for the Scintilla Magneto Division of Bendix Aviation Corp., Sidney, N. Y.

DANIEL O. SIKES, formerly division lubrication sales engineer with the Gulf Refining Co., Toledo, Ohio has now become fleet marketer for that organization in New Orleans, La.

ERROL S. EVANS is now district manager of California Oil Co., McKees Rocks, Penna. His previous position was that of manager - sales technical with the same company in Barber, N. J.

P. E. IRVING has resigned his position as Chief Engineer to the Vincent H.R.D. Co., Ltd., Stevenage, Herts., England in order to return to his native Australia. His new position is development engineer for the Chamberlain Industries, Pty. Ltd., Port Melbourne, Victoria, whose main business is the production of an all-Australian heavy farm tractor.

KEITH ENGELBART is now an engineering draftsman with Beech Aircraft, Wichita, Kans.

GERALD HENRY BALZER, a graduate of Northrop Aeronautical Institute, is now an illustrator "B" with Northrop Aircraft, Inc., Hawthorne, Calif.

CARMINE G. MONTANARO, JR., who graduated last February from the Northrop Aeronautical Institute, has joined Northrop Aircraft, Inc., Hawthorne, Calif. as an inspector.

RICHARD J. ROBERTS is now a test engineer with the Marquardt Aircraft Co., Van Nuys, Calif. He is a graduate of the Northrop Aeronautical Institute.

OBITUARIES

ROY E. COLE

Roy E. Cole, retired vice-president of engineering of the Studebaker Corp. died in Memorial Hospital, South Bend on April 19. He was 67 years of age and had been seriously ill for several months.

From his entry into the automobile world as a draftsman for the Chalmers Motor Car Co. in 1909 until his death, Cole maintained an intense interest in the automotive industry. Perhaps he is best known for his accomplishments in the span from 1925, when he joined Dodge Brothers as assistant chief engineer, until 1948 when he retired as Studebaker's vice-president of engineering. One of his major achievements was the Studebaker Champion which was introduced in 1939.

During the first world war he took an active part in the standardization of the military truck for the War Department and in the second world war it was under his supervision that Studebaker developed and produced the M-29 cargo and personnel carrier, commonly known as the "Weasel."

Born and educated in Ohio, his loyalty to Ohio State University, where he studied mechanical engineering, was much in evidence during the football season. It was always difficult for him to pass a store window displaying anything new in the line of guns or photographic equipment and his skill with both gun and camera justified the excellence of his equipment. In recent years, with his wife and two daughters, he spent much of his spare time cruising on Lake Michigan. Of his host of friends there are few who have not at some time enjoyed his hospitality aboard either the Skål I or Skål II.

His service to SAE includes a term as Vice-President for the Passenger Car Activity in 1943. During World War II he served on the SAE War Engineering Board and became a member of the SAE Technical Board when it was formed in 1945.

THOMAS M. WALSH

Thomas M. Walsh, superintendent of maintenance for the Neibauer Bus Co. passed away March 7 in Harrisburg, Pa., after an illness of several months. He was 46 years old.

He was born in Ireland, where he received his education and served for two years in the army as a first lieutenant. After coming to this country in 1925, he worked as a foreman in bus maintenance for the Baltimore Transit Co. In 1947 he became superintendent of maintenance for the Neibauer Bus Co. in Bristol, Pa., a position he held until his death.

Walsh joined the Society in 1944.

COL. GILBERT JERROLD

Col. Gilbert Jerrold, assistant air attaché and chief of the purchasing mission for the French Air Force, died April 13 at the age of 41. He had been a member of the Society for 13 years.

He attended the Ecole Polytechnic and the Ecole Nationale Superieur de l'Aeronautique in Paris, and was employed by the French Government throughout his career. For the first four years he worked successively in experimental work on aircraft engines; specifications and requirements for aircraft engine accessories; and ground and flight tests on airplane engine installations. Later he was stationed in Algiers as engenieur en chef de l'air. He had been stationed in Washington for two years before assuming his last position in 1948.

ANDRÉ E. MANDEL is now consulting engineer and assistant to the president at Manufacture d'Armes de Paris. Previously, he was a consulting engineer for another company.

EDWARD S. KELLERMANN, JR., a graduate of the University of Minnesota, has become a designer and junior mechanical engineer for the National Pressure Cooker Co., Eau Claire, Wis.

JOHN AMOROSO is now a resident engineer for the Houdaille-Hershey Corp., Houdé Engineering Division, Buffalo, N. Y. He is their representative at the Honan Crane Corp., Lebanon, Ind. who are manufacturers of oil purifiers, conveyors, and special equipment.

HUDSON T. MORTON, formerly standards engineer with the Fafnir Bearing Co., New Britain, Conn., is now president of the Morton Bearing Co., Ann Arbor, Mich. Mr. Morton has served in various capacities on SAE committees.

DANIEL W. SMITH, JR., is now employed with the Hupp Corp., Detroit, Mich. as sales engineer. He was previously connected with the Evans Products Co., Plymouth, Mich. as manager of the stampings division.

WALTER UNTERBERG is now connected with the Marquardt Aircraft Co., Van Nuys, Calif. in the capacity of test development engineer. He formerly was with General Motors Institute, Flint, Mich., as an instructor in the drawing and design dept.

ARDEN J. MUMMERT was elected president of the McQuay-Norris Mfg. Co. on April 17. Mummert became associated with McQuay-Norris as an engineer in 1914 and was one of the early specialists in automotive engineering. He was made a vice-president in 1934 and since 1946 has been executive vice-president.

CHARLES W. M. COOTE is now president of the Charles W. M. Coote Co., Inc., West Orange, N. J. He was formerly regional sales manager for Marlow Pumps, Ridgewood, N. J.

J. RUSSELL TUTT, formerly with Superior Coach Corp., Lima, Ohio, is now connected with Ornas and LaBarre, Centerline, Mich.

WILLIAM WILSON, a recent graduate of the University of Oklahoma, has joined the Oklahoma Natural Gas Co., Tulsa, Okla. as an engineering trainee.

WALTER B. HODAPP a graduate of Notre Dame, has joined the Bendix Products Division of the Bendix Aviation Corp. as a junior engineer.

AUGUST E. MAIER has become a junior engineer with Lydon Brothers, Inc., Hackensack, N. J. He is a recent graduate of Indiana Tech.

Continued on p. 96

CALENDAR

Canadian—June 15

Kitchener — Golf Tournament. Prizes will be awarded to the good golfers and the lucky ones.

Central Illinois—June 12

Hotel Jefferson, Peoria, Ill.; dinner 6:30 p.m. Meeting 7:45 p.m. Why Heavy Duty Type Motor Oil—J. M. Miller, head of auto division, Standard Oil Co. of Indiana.

Milwaukee—June 17

Ladies Nite. (Dinner-Dance 7:00 p.m.)

New England—June 20

Marlboro Country Club. All day annual outing — golf, dinner, auto show, and floor show.

Northern California—June 19

Engineers Club, San Francisco, Calif.; dinner 6:30 p.m. Aeronautics Meeting. Speaker and subject to be announced.

St. Louis—June 17

Bippen's Grove on Gravois Road—½ mile west of Grant's (Busch's) Farm; all day picnic, for SAE members and friends. Soft ball game between the Fats and Leans. Also horseshoe pitching, badminton, cards, refreshments.

Spokane-Intermountain—June 8

City Club; dinner 7:00 p.m. Ladies Night—banquet and dance.

Twin City—June 14

Minnesota Mining and Mfg. Co., St. Paul, Minn.; dinner 6:30 p.m. Meeting 7:30 p.m. Topic: Coated Abrasives. An inspection trip.

Williamsport Group—June 5

Antler's Club, Williamsport, Pa.; dinner 6:45 p.m. Ladies Night—dinner and dance.

NATIONAL MEETINGS

MEETING	DATE	HOTEL
SUMMER	June 4-9	French Lick Springs, French Lick, Ind.
WEST COAST	August 14-16	Biltmore Los Angeles, Calif.
TRACTOR	Sept. 12-14	Schroeder Milwaukee, Wis.
AERONAUTIC and AIRCRAFT Engineering Display	Sept. 27-30	Biltmore Los Angeles, Calif.
TRANSPORTATION	Oct. 16-18	Statler, New York City
DIESEL ENGINE	Nov. 2-3	Knickerbocker Chicago, Ill.
FUELS and LUBRICANTS	Nov. 9-10	Mayo Tulsa, Oklahoma
	• 1951	
ANNUAL MEETING and Engineering Display	Jan. 8-12	Book-Cadillac, Detroit
PASSENGER CAR, BODY, and MATERIALS	March 6-8	Book-Cadillac, Detroit
AERONAUTIC and AIRCRAFT Engineering Display	April 16-18	Statler, New York City

TECHNICAL COMMITTEE *Progress*

New SAE Manual Tells How To Design Coned Disk Springs

THREE ways to design coned disk or Belleville springs and two ways to make them are detailed in the recently-completed SAE Manual, Design and Manufacture of Coned Disk Springs. Prepared by the SAE Spring Committee, the new Manual is the fifth in an SAE series on springs. (The other four cover helical and coil, leaf, volute, and torsion bar springs.)

Belleville springs, some of which are shown in Fig. 1, are circular disks with holes, dished to a conical shape. Applying a load tends to flatten the disk. The deformation makes for the spring action.

Belleville springs are used in gun recoil mechanisms; as spring washers to give constant bolt loading or gasket pressure; in tailstock centers to take up expansion of work at constant thrust; and in clutches to apply load to friction plates.

Their load-deflection characteristics can be varied, the Manual points out, by changing the ratio between initial cone height, h, and thickness, t. (See cross-section in Fig. 1.)

Two Types of Stacking

Belleville springs may be used singly, or stacked in parallel or series, as in Fig. 2. Stacking in parallel increases load capacity in proportion to the number of springs. Friction between

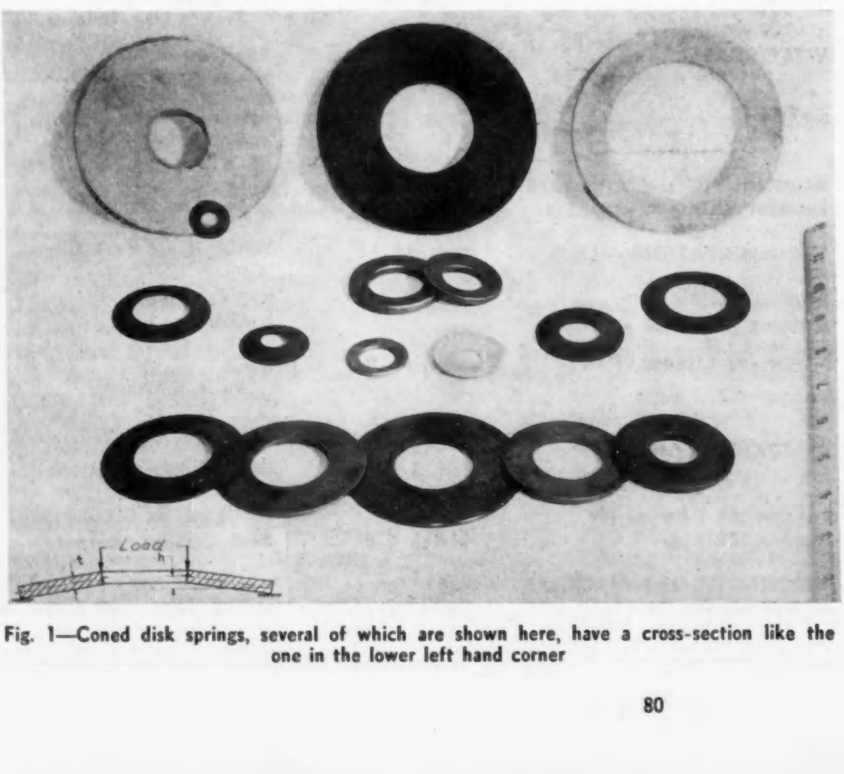
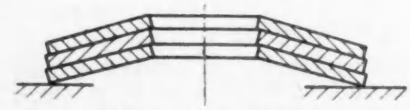


Fig. 1—Coned disk springs, several of which are shown here, have a cross-section like the one in the lower left hand corner



(a) STACKED IN PARALLEL

(b) STACKED IN SERIES

Fig. 2—Ways of stacking Belleville springs

the springs also provides damping. Stacking in series raises the deflection for a given load in proportion to the number of discs. Spacers between springs stacked in series make possible deflections greater than total cone height.

Design Methods

Coned-disk spring stresses and deflections can be calculated by three different methods, according to the design section of the Manual. They are:

1. Elastic Coned-Disk Method. This involves two assumptions: (1) that the material behaves elastically, and (2) that radial cross-sections will rotate without distortion during deflection.

2. Elastic Flat-Plate Method. Where both cone height and deflection are small relative to thickness, this method can be used. The formulas are simplified based on the elastic flat-plate theory.

3. Nominal Stress Method. This approach gives reasonable stress values for static loading conditions.

Charts in the Manual help simplify the calculations by these three methods. A worked-out design example illustrates use of both the charts and formulas.

Materials Used

These springs generally are made of carbon or alloy steel. For special purposes, stainless alloys and nonferrous materials are used. Belleville springs come in two quality grades—commercial and special grade. The special grade is more precisely made and costs more. A glance at the fabricating processes for each, described in the Manual, points up this difference.

Fabrication Detailed

Manufacturing procedure for the commercial grade consists of these steps: (1) the stock is sheared cold into square pieces; (2) the piece is heated and the center hole hot-punched to form the ID; (3) it is again heated and hot-blanked in dies to form the OD; (4) next the blank is heated and pressed in conical dies; (5) heating to proper temperature and quenching follows; (6) the spring is tempered to desired hardness; and (7) tested and inspected.

Additional Processing

The special grade, made of oversize thickness stock, requires these plus several other operations. The stamped ID and OD are finish machined. Spring surfaces and bearing flats are ground. And the spring is cleaned both before and after the finishing operations.

Allowable height variations and manufacturing tolerances also are tabulated in the Manual.

Copies of the Manual are not yet available; but the SAE Special Publications Department plans to publish and distribute it.

Members of the Coned Disk Spring Committee, of the SAE Spring Committee, which developed the Manual, are: Dr. A. M. Wahl, Westinghouse Electric Corp., chairman; J. O. Almen, General Motors Corp.; H. H. Clark, Eaton Mfg. Co.; H. A. Curtis, Rock Island Arsenal; Dr. H. O. Fuchs, PRECO, Inc.; Andrew Lawrence, Hy-Score Arms Corp.; Prof. C. W. MacGregor, Massachusetts Institute of Technology; W. E. McKim, Union Spring & Mfg. Co.; Maurice Olley, Vauxhill Motors, Ltd.; Robert Schilling, General Motors Corp.; Bernhard Sterne, Chrysler Corp.; T. R. Weber, American Locomotive Co.; and F. P. Zimmerli, Associated Spring Corp.

Chairman of the SAE Spring Committee is Torre Franzen, Chrysler Corp.

Technishorts . . . . .

EXTRUDED MAGNESIUM ALLOY: Use of extruded magnesium alloy ZK60A is growing in aircraft manufacture. The material's strength, toughness, and fatigue resistance—in the heat-treated and aged condition—make it useful in structural parts. (For discussion of ZK60A properties, see SAE Journal, April, 1950, p. 69, "Properties of ZK60A—A Magnesium Extrusion Alloy," by E. H. Schuette.) An SAE Aeronautical Materials Specification is being planned for the material.

COLD-FINISHED STEEL: An Army Ordnance-sponsored research program at the Case School of Applied Science, Cleveland, is aimed at learning more about the fabricating and physical properties of cold-worked steels. The Cold-Finished Steel Division, of the SAE Iron & Steel Technical Committee, plans to coordinate its own program, underway for several years, with the one at Case to eliminate any duplication.

TRACTOR WHEELS: A new wheel size has been added to the SAE Recommended Practice for Tractor and Implement Disc Wheels. It is a 12-in. diameter size with a 1¼-in. offset. This addition now provides for interchangeability of 16, 15, and 12-in. tractor and implement wheels.

MEASURING DECARB: Steel decarburization is being checked in three ways, according to a recent survey of the Seam Depth and Decarburization Division, of the SAE Iron & Steel Technical Committee. They are: microscope, used mainly for rods, wire, leaf springs, and bars; file hardness test, for tubular products and bearings; and the spark and chemical tests. The group, cooperating with ASTM and the American Iron & Steel Institute, hopes to prepare information on decarburization measuring methods for the SAE Handbook. (Heat-treating and annealing cause decarburization by oxidizing carbon from the outside skin of the steel. Because the trend is away from carburizing and toward higher carbons, the decarb problem is becoming more critical.)

Stall Warning Device Called a Flight Need

RESEARCH into the training of pilots with respect to airplane stall has pointed up the need and desirability of a stall warning indicator, Prof. P. J. Rulon, of Harvard University and the Educational Research Corporation, recently remarked at a meeting of the SAE Committee on Aircraft Instruments. The Committee now is preparing a recommended practice for performance of these instruments.

Three Conclusions

Rulon disclosed three conclusions resulting from Educational Research's work with hundreds of pilots and showed how CAA action has reflected these results. The findings are:

1. The average pilot cannot be trusted to sense the impending stall.

2. Individuals who do correctly sense the stall do it by such complicated methods that it is unreasonable to expect private pilots to learn these techniques and remain skilled through practice.

3. In the light of (1) and (2), a stall warner should be installed on civil aircraft, particularly on private airplanes.

Impracticability of training pilots to sense the very edge of stall, or of expecting them to retain that ability, was proved by the Educational Research project. Hundreds of students, flight instructors, and private pilots were tested during this project and only a small proportion exhibited this ability. CAA had previously required this of pilots before giving them a license.

Continued on p. 82

Drs. Brimhall and Franzen of the CAA, Rulon reported, found that many serious airplane crack-ups stemmed from the pilot's inability to recover from a stall. For example, in coming in for a landing, the pilot may find himself making an undesirable approach and wants to circle again to make another attempt. In doing so, he brings the nose of the airplane up to gain altitude and may hit a stall condition. The airplane goes out of control, and since it is so close to the ground, it crashes before the pilot can bring it out.

Some few pilots can detect accurately the approach of a stall condition. Rulon said that only about a dozen of the hundreds tested could do this. These few could and did describe just how they detect the condition. But the methods are intricate, and it varies with whether the airplane is banking to the left, to the right, or flying straight ahead. In fact, detection techniques would also differ with each type of airplane. Such complicated procedures, the research group concluded, would be too much to expect of the private pilot.

Another phase of this project dealt with recovery from stall—how to best remedy the stall condition if ever encountered. From data gathered in making 5000 stalls at 600 ft altitude in a Piper J-3 trainer, E.R.C. researchers learned that the then-recommended CAA procedure could be improved in certain situations. CAA had recommended that stall recovery be made with the nose of the airplane (in this case the Piper J-3) pointed down. E.R.C. found that much less altitude would be lost in trying for a recovery from power-on stall by returning the nose to the horizon. In the Piper J-3, recoveries from stall could be made within an altitude loss of only about 20 ft by this technique.

However, the pilot never need face such a situation, Rulon asserted, if a stall-warning indicator alerted him that the airplane was rapidly approaching a stall condition. (This usually is done by buzzing horn and light signal.) Rulon pointed out that small factions are resisting use of the instrument—such as we-fly-by-the seat-of-our-pants pilots. Others feel uncomfortable about relying on an instrument which may at some time fail. Yet these same flyers would not fly without a tachometer, altimeter, or airspeed indicator.

Dr. D. R. Brimhall, Civil Aeronautics Administration, informed the SAE Committee that the CAA has taken cognizance of these findings. In fact, the recommended practice on performance of stall warning indicators being developed by the SAE was requested by CAA as a framework on which to build a CAA Technical Standard Order for certificating such instruments.

Because CAA believes in the advisability of a stall warning indicator on airplanes, its requirements for licensing private pilots have also been modified, according to Brimhall. Pilot license applicants no longer are required to be able to detect the edge of a stall. And CAA recommendations for stall recovery with the Piper J-3 are being changed to urge study of the airplane used, to find the best way for that airplane.

Coordinating Research Council Balance Sheet

The Audited Balance Sheet and Operating Statement of the Coordinating Research Council, Inc., for the fiscal year ending December 31, 1949, are given below. The Coordinating Research Council is owned by its two Sustaining Members, the American Petroleum Institute and the Society of Automotive Engineers.

Balance Sheet as of Dec. 31, 1949

Assets	
Cash	$ 45,930
Accounts Receivable and Accruals	45,935
U. S. Savings Bonds	59,360
Other Assests	1,339
Total	$152,564
Liabilities and Reserves	
Accounts Payable	$ 37,958
Contribution—Diesel Railroad Project, portion applicable to 1950	8,353
General Reserve	106,253
Total	$152,564

Operating Statement for Year Ending Dec. 31, 1949

Income	
Contributions:	
American Petroleum Institute	$ 25,000
Society of Automotive Engineers	25,000
Other contributions	54,408
Military contracts received and accrued	76,461
Other income	1,987
Total	$182,856
Expenses	
Coordinating Fuel & Equipment Research Committee:	
Motor Fuels Division	$ 53,043
Aviation Fuels Division	24,608
Diesel Fuels Division	27,705
Coordinating Lubricants & Equipment Research Committee	12,976
U. S. Army Ordnance	22,906
U. S. Air Force	12,689
U. S. Navy	42,556
Total	$196,483
Excess of Expense over Income	$ 13,627
General Reserve, Jan. 1, 1949	119,880
General Reserve, Dec. 31, 1949	106,253

Auto Glazing Standard Being Brought Up-to-Date

PROPOSED revision of the American Standard Safety Code Z26.1/35, on motor vehicle safety glazing materials, for the first time approves the use of transparent plastic glazing in certain openings in motor vehicle bodies or cabs. It has been completed and sub-

mitted to the two sponsors for approval. SAE participated in the preparation of this revision through representation on the Sectional Committee.

In addition to allowing plastic glazing (only in certain openings), the proposed Standard sets up test specifications for these materials. Plastics can be used in locations not requiring driving visibility, such as in interior partitions, auxiliary wind deflectors, and folding doors. They cannot be used in windshields.

Heat-absorbing glass, now coming into use, also falls within the revised requirements of the proposed Standard. Because this material transmits less light than ordinary safety glass, the 70% light transmittance requirement is relaxed for that portion of a glazing sheet having heat-absorbing qualities. But portion of the material needed for driving visibility must satisfy the 70% minimum.

Wire Glass Restricted

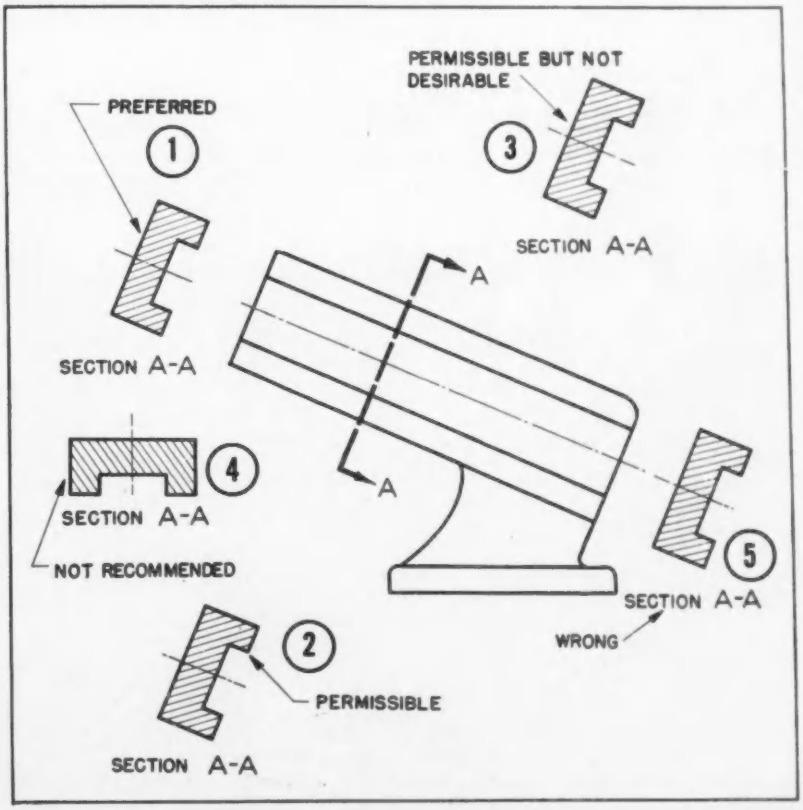
The proposal also limits use of wire glass to certain truck and bus windows. The old Standard permitted its use on all vehicles and all windows, except the windshield.

Sponsors of this project are the Accident Prevention Department of the Association of Casualty and Surety Companies, and the National Bureau of Standards. When approved by both sponsors, the proposal will be submitted to ASA for final approval and identification as an American Standard.

SAE representatives serving on ASA Sectional Committee Z26, which prepared the proposal, are: C. E. Heussner, Chrysler Corp.; J. L. McCloud, Ford Motor Co.; H. C. Mougey, General Motors Corp.; B. F. Jones, Autocar Co.; and R. E. VanDeventer, Packard Motor Car Co.

Recommendations by the SAE Plastics Glazing Committee, on studies it made several years ago, were considered by the Sectional Committee in developing the revised Standard.

How To Place Sectional Views



There are right and wrong ways of showing sectional views on drawings, notes SAE Committee S-1 in its instructions on sectional views, recently approved for inclusion in the SAE Aeronautical Drafting Manual. Wherever practicable, the Committee advises, place the sectional view behind the cutting plane arrows, as in (1). On drawings where space is restricted, the sectional view may be shown elsewhere, but shown as projected from the cutting plane arrows. See (2) and (3). But never rotate the axes of the sectional view, the case in (4). It's also wrong to place the projection ahead of the cutting plane arrows, as shown in (5).

Uniform Dimensioning Sought for Jet Blades

A UNIFORM method of dimensioning aircraft turbine blading, a new project of the SAE Aeronautical Drafting Manual Committee, holds promise of significant inspection time and cost savings.

The wide variety of dimensioning systems now used by turbojet and turboprop engine manufacturers place a hardship on the blade supplier. He must invest in gages and tooling for inspecting blades dimensioned by different systems, notes John Dziel, Ranger Engine Division, Fairchild Engine & Airplane Co., chairman of the subcommittee tackling this program.

A turbine blade or bucket has no natural base or reference point for dimensioning because of its shape. Some companies dimension from a developed chord line; several take the leading or trailing edge; and still others dimension using coordinates. Inspection set-ups differ for each dimensioning system.

Because of the high cost of installing or adapting inspection tooling for each dimensioning system, the subcommittee hopes to develop a standard method of dimensioning turbine blades. Preliminary discussions also show this will aid inspection equipment makers by cutting down the diversity of gages and inspection tooling called for. The subcommittee plans to consult with design engineers as well as inspection men in developing a uniform dimensioning system.

JOHN DZIEL

Chairman, Subcommittee on Methods of Dimensioning Turbine Blade and Bucket Shapes of the SAE Aeronautical Drafting Manual Committee

Serving with Dziel on the subcommittee are: R. W. Henry, Pratt & Whitney Aircraft; P. V. Richards, Wright Aeronautical Corp.; L. R.

Smith, Allison Division, GMC; H. A. McFarland, General Electric Co.; and E. W. Egee, Westinghouse Electric Co.

SAE Group to Review Ordnance Steel Spec

A NEWLY organized group under the SAE Iron & Steel Technical Committee has been formed specifically to review the proposed Army Ordnance Specification for Steel, Parts for Ordnance Materiel. Named the Ordnance Specification Review Division, this group will serve as the agency for developing automotive opinion for Ordnance on this selection specification.

E. H. Hergenroether, International Nickel Co., is chairman of the new Division. Members include M. L. Frey, Allis-Chalmers Mfg. Co., chairman of the SAE Iron & Steel Technical Committee, and members of the five ISTC panels—Steel Producers, Castings, Automotive, Tractor and Earthmoving Equipment, and Miscellaneous Users.

'Copter Report Spots Potential Design Gains

DESIGN keyed to helicopter operation will yield standardized braking methods and weight saving in wheels and tires. This is pointed out in the newly-issued SAE Aeronautical Information Report No. 15A, Desired Characteristics for Helicopter Wheels, Tires, and Brakes.

Break design should suit two operating needs, says the Report: (1) deceleration and steering, and (2) hovering landing on inclined surfaces and parking.

It shows that the brakes must be relied on entirely to decelerate the craft when landing, despite the ability of most helicopters to land from an autorotative or power-off glide with little or no ground roll. In emergencies or training flights the machine sometimes lands with forward speeds as high as 40 mph.

Normally the rotor may help decelerate during ground roll; its rpm may even increase as the stick is pulled back, notes the Report. But you can't always count on this effect, because the pilot may have dissipated so much energy while still airborne that the rotor stalls and helps little in checking ground roll. The wheel brakes must do the entire job in this situation.

The brakes should be able to stop the machine within 200 ft from an initial speed of 40 mph. At constant deceleration, this gives the brakes 6.8 sec within which to absorb the energy of the gross weight moving at 40 mph. Brakes rated to absorb 75% of the capacity should be satisfactory, since this is an emergency condition, and endurance is not a consideration.

Need for individually-operated brakes for steering depends largely on the particular design, says the report. If the rotor provides normal flight-directional control during ground roll, individual wheel brakes are not needed.

Brakes should be able to hold the helicopter on at least a 15-deg slope for inclined-surface landings. Pilot-controlled locking pins in wheels should serve only to prevent roll after landing, and for parking on slopes in land operations.

For shipboard landings, brakes must meet a 20-deg slope requirement. And locking pins won't work for deck handling. High winds and rolling decks dictate mooring. Braking also should counteract any unbalanced torque acting on the wheels when engaging the rotor.

The Report recommends brake operation from the cockpit, by a single hand or foot-operated control. It specifies no particular brake design and considers adequate any standard aircraft wheel brake system, either mechanically or hydraulically operated.

Conventional airplane brake systems can be modified to suit helicopters by reducing brake energy capacity, advises the Report.

Weight-Saving in Tires

Tire makers also are making special helicopter tires. They save weight by reducing tread and sidewall rubber. The Report sees need for still larger tires with no increased weight to permit landing on soft ground, sand, and mud. Because helicopters will make few landings with forward speeds, the tires need not be designed to wear as long as those for airplanes. But wear due to side scuffing should be considered.

Members of the SAE Helicopter Committee, which prepared the Report, are: J. P. Perry, Eastern Rotorcraft, chairman; L. L. Douglas, Kellett Aircraft Corp.; F. B. Gustafson, NACA; M. Jensen, Canadian Car & Foundry Co.; B. Kelley, Bell Aircraft Corp.; D. R. Jacoby, United Helicopter, Inc.; Com. J. W. Klopp and R. A. Young, Navy Bureau of Aeronautics; C. A. Kuehne, USAF Air Materiel Command; R. Osborn, McDonnell Aircraft; Frank Piasecki, Piasecki Helicopter Corp.; and S. H. Rolle, Civil Aeronautics Administration.

You'll Be Interested to Know . . .

TWO NEW STUDENT BRANCHES have been established—one at University of Colorado (Boulder, Colo.), the other at Aeronautical University (Chicago, Ill.). . . . The SAE Student Club from which the U. of C. Branch grew was organized in 1945, had 120 members. SAE Member Robert F. Brown is faculty adviser. . . . The New Aeronautical U. Branch had 63 members in its predecessor SAE Student Club. Dean Alfred Scott is faculty adviser.

ALEXANDER KARTVELI, Republic Aviation Corp., has been named an SAE representative on the Daniel Guggenheim Medal Board of Award, to complete the unexpired term of the late J. M. Shoemaker which ends Oct. 1, 1951.

EARL BARTHOLOMEW, Ethyl Corp., will serve as SAE representative on the National Committee for USA for the 3rd World Petroleum Congress. The Congress will be held at The Hague, Netherlands, from May 28 to June 6, 1951.

GEORGE HUEBNER, chief engineer of research, Chrysler Corp., will be the SAE member of a USA and Canada Program Committee of the Conference on Heat Transmission scheduled for London, Sept. 11–13, 1951. The Conference is under the joint auspices of the American Society of Mechanical Engineers and the Institution of Mechanical Engineers (Great Britian).

ADDITIONAL MEMBERS have been named to several SAE Professional Activity Committees since appointment of the original committees for 1950 as listed in the 1950 SAE Roster. The additional appointments include: To the Body Activity Committee and the Body Activity Meetings Committee—G. M. Buehrig. . . . To the Diesel Activity Committee— C. G A. Rosen. . . . To the Passenger Car Activity Committee—C. J. Lauer. . . . To the Tractor & Farm Machinery Activity Committee and the Tractor & Farm Machinery Activity Meetings Committee—J. P. Carroll. . . . To the Transportation & Maintenance Activity Committee—Henry Jennings. . . . To the Truck & Bus Activity Meetings Committee—L. W. Fox. . . . To the Truck & Bus Activity Membership Committee—P. A Collins.

SAE Section Meetings

Owners Don't Drive To Get Best Economy

• British Columbia Section
J. B. Tomkins, Field Editor

March 13 — Today as never before, maximum performance economy is the goal of most automobile owners, said **Wilmot Sandham,** automotive engineer at General Petroleum Corp.

Despite the earnest desire, few among them get anywhere near the mileage potential which is built into their 1950 automobiles and gasolines. Most are woefully lacking in knowledge of driving techniques which could improve their mileages. Many lack the remotest idea as to whether their vehicles should, under favorable conditions, deliver 16, 20, 24, 28, or any specific number of mpg.

Sandham told about a 751-mile cross-country trip he headed along California, Nevada, and Arizona highways in mid-February. His narrative was not of his own experiences, but of the caravan of 31 stock-model 1950 sedans of assorted makes which followed his pilot car out of Los Angeles over a largely-desert route to the Grand Canyon's south rim.

Comparable test runs have been staged at intervals since 1936, the most recent in 1941. This year's trials produced no new ton-mileage records, but engineers were jubilant over apparently improved efficiency since speeds average 10 mph better than those clocked in 1941. Winning mileage per gallon was 26.55.

Jet Engine Movies Shown

• Baltimore Section
E. C. Plackman, Assistant Field Editor

April 13—Jet engines will answer many problems of commercial airlines, according to **Mark C. Benedict,** chief of the installation section of Westinghouse Electric Corp.'s gas turbine division. Benedict showed color slides and motion pictures of jet engine construction and application, and illustrated with schematic drawings of single- and two-stage compression jets how weight, power and drag problems are being solved with improved designs.

Jet engines, he said, can be economically justified on long-hop, one-stop schedules.

Details Research On Exhaust Pipes

• Williamsport Section
William Ribando, Field Editor

Feb. 6—The proper design and choice of an exhaust system for an internal combustion engine aids substantially in increasing the power output, **Dr. P. H. Schweitzer,** of the Pennsylvania State College, reports.

The exhaust system is usually neglected and considered a nuisance, but there is recoverable energy in the engine exhaust. About one-third of the fuel energy generally goes out the exhaust, of which 6 to 10% is recoverable. This figure approaches 34% at altitudes of 30,000 ft.

Energy in the exhaust may work for you and against you. It usually is against you but can be made to work for you by proper selection of an exhaust system.

A properly tuned exhaust system may mean an increase of 30% over a poorly tuned system in a single-cylinder two cycle engine. Exhaust pressures propagate in waves in the exhaust pipe. A pressure wave is generated by the exhaust blowing down into the pipe. The pressure wave travels along the pipe and returns from the open end. If the natural frequency of the exhaust system is equal to the engine speed, you have the worst pipe length. If the pipe is tuned, so that a vacuum wave is present when the exhaust opens and that turns to positive pressure when the exhaust closes, the best possible tuning is achieved. In a multi-cylinder engine interference is most important; that is, the exhaust of one cylinder is obstructed not so much by the returning wave from the stack but by the exhaust of another cylinder. If a cylinder exhaust blows down while in an adjacent cylinder the exhaust is open, the exhaust will propagate into that

Gene May, Douglas test pilot, chatting informally with Northrop students after showing films of important flights of Douglas Skystreak and Skyrocket planes at their April 6 meeting

cylinder and obstruct the exhaust and charging of that cylinder. How bad it is depends on the number of cylinders and on the firing order.

The problem resolves itself in finding such shapes of exhaust pipes which minimize or prevent exhaust interference. A good manifold produces a partial vacuum. This was achieved by the use of quarter round exhaust branches, venturis, and separator vanes or the introduction of a smaller tube in the exhaust manifold, to lead the exhaust of an offending cylinder beyond the danger point into a venturi. This design exceeded all expectations, and was even better than no exhaust manifold at all in that instead of creating a back pressure, the aspirator type manifold with venturis created a vacuum. Instead of opposing the charging of the cylinders, it helps it by the suction effect.

Frequent Oil Change Called Advantageous

• Pittsburgh Section
H. Kenneth Siefers, Acting Field Editor

April 25—The work of saving oil has been carried too far for real economy, said **L. T. White** of Cities Service Oil Co., adding that more frequent oil drains will pay big dividends.

He pointed out that although engine speeds, temperatures, and pressures have increased, this has been detrimental to over-all operating and maintenance economy.

Emphasis was placed on the important and often-overlooked duties of the oil in aiding combustion and power generation during the four strokes of the engine by sealing the piston and lubricating the rubbing surfaces; even less frequently considered are unfavorable effects on oil of accumulated soot, moisture and ash from fuel as well as solids breathed in with the air supply. Few cars have a thorough air cleaning system, and shorter drain periods help reduce operating costs.

White cited concrete cases to prove his points: Results of tests conducted by L. L. Pernot of Four Wheel Drive Auto Co. showed that the fleet with lowest oil lubricating costs had the highest total cost, and vice versa. Other fleet tests indicated that complete oil screen plugging would be encountered in less than 15,000 miles of service when 6000-mile oil drains were used. Total plugging would not occur during the life of the engine at drain periods of 1000 miles. A group of 43 vehicles operating under clean combustion and clean lubrication conditions ran more than 100,000 miles without removing cylinder heads.

Peoria's Voted

April 11-13—An idea born a year and a half ago reached dramatic climax this week as 600 SAE members and guests (some from as far away as Sweden and South Africa) attended the second largest convention held in Peoria for the last several years.

From early Tuseday morning until Thursday evening, those present at this first Earthmoving Industry Conference were treated to a full program of four technical papers, a banquet talk by William Hazlett Upson, and several plant visits.

General Chairman R. C. Williams opened the meeting in the packed Grand Ballroom of the Pere Marquette, and introduced Keynote Speaker R. G. LeTourneau, president and chief engineer of R. G. LeTourneau, Inc., who told of early experiences and development work 30 years ago when earthmovers had their choice of the compressed-air-driven Smithner and the belt-driven Holt. What is revolutionizing the industry today, he said, are weight and speed. When he began it was possible to move about three cubic yards at a rate of 2 mph; now 60 yards can be moved at 30 mph. Despite high increases in prices, wages, and materials, contractors move dirt just as cheaply as they did then. Efficiency has kept pace.

Session chairman T. M. Fahnestock, manager of Caterpillar Tractor Co.'s opened the first technical session by presenting R. F. Bourne of Colorado Fuel & Iron Corp., who showed a color movie on steelmaking and spoke on "Cutting Edges as Applied to Grader, Scraper, and Bulldozer Requirements and Specifications." Bourne said that alloys and heat treatment have not provided answers to improving wear in cutting edges, especially grader blades. In general, he suggested, grader blades of $\frac{5}{8}$-in. plain carbon steel of AISI-C-1085 are best for average grader jobs; bulldozer blades of AISI-C-1060 or 1065 plain carbon steel are superior, and cast manganese steel edges for rocks and boulders; and scraper cutting edges heat-treated and hard-faced by the factory will give best performance

Chairman for the afternoon session was T. A. Haller, assistant chief engineer of Allis Chalmers Mfg. Co. E. F. Norelius, consulting engineer for Allis Chalmers, reported that there is a

DINNER SPEAKER William Hazlett Upson (center) with Toastmaster Paul Benner (left) and C. G. A. Rosen, who introduced Upson

PLANNING COMMITTEE for the conference: Left to right: Paul Benner, Mitchell McMurray, Bill Sydnor, Russ Williams, Woodrow Kimsey, and Francis Rother; all of Caterpillar Tractor Co.; and John T. Liggett, Allis-Chalmers Mfg. Co. Committee members not on hand for the picture were Russell Rand, Bob Kennemer, and Ted Fahnestock, of Caterpillar, and Bob Fletcher, of Hyster Co.

KEYNOTE SPEAKER R. G. LeTourneau

Earthmoving Conference Outstanding Success

• Central Illinois Section
Ivan Lamport, Field Editor

possible place for "Infinite Ratio Transmissions" wherever there is now a step gear transmission of any type. Even where a step gear is not required, it is still advantageous to use an infinite ratio transmission wherever the load must be started from rest.

His confidence in the future of hydraulic transmission was echoed by R. M. Schaefer, who spoke on "Going to Work with Hydraulic Transmissions." The chief engineer of the commercial transmission department of GMC's Allison Division showed results of a study of 75 comparisons in different locations and services that indicated an average reduction of 7.5% in cost per yard on vehicles using hydraulic transmissions.

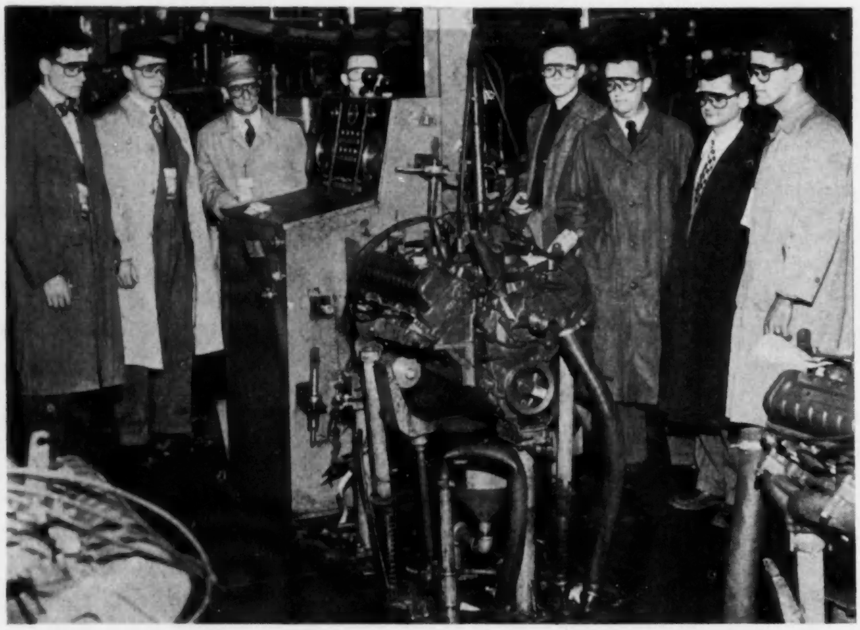
Highlight of the Conference was the Tuesday evening banquet presided over by Toastmaster Paul Benner, chairman of Central Illinois Section. After crediting various committee members with the Conference's success, Benner turned the meeting over to C. G. A. Rosen of Caterpillar, who introduced Speaker Upson, well-known author and creator of "Alexander Botts." Upson told some of his stories based on experiences years ago as a serviceman for Holt Mfg. Co., predecessor of the present Caterpillar Tractor Co. A good salesman, Upson suggested, is not only one who can talk back to his boss but one who is smart enough to do, not what his boss tells him to, but what he would tell him to if he knew what he was talking about. Upson's stories were proved to be better than 80% absolute truth by the delegate from South Africa, who turned out to be his former boss at Holt.

Final technical session, chairmanned by D. K. Heiple, chief field engineer for LeTourneau, featured a paper on "The Steering of Rubber-Tired, High-Speed, Off-the-Road Earthmoving Units," by G. J. Storatz of Heil Co. Storatz described steering mechanisms used on current production rubber-tired off-the-road earthmovers, and predicted further improvements and refinements to keep pace with speed and maneuverability demanded of this equipment.

Importantly responsible for the success of this three-day meeting were R. L. Williams, chairman; R. E. Kennemer, treasurer; Bill Sydnor, program chairman; Russell W. Rand, publicity; Mitchell McMurray, secretary; Francis J. Rother, mailing list, announcements and registration; Woodrow Kimsey, arrangements; Ted Fahnestock, plant tours; and Bob Fletcher, finances.

PRESENT AT THE CONFERENCE were most members of the SAE Construction and Industrial Machinery Committee: Left to right: Peter P. Polko, International Harvester Co.; E. C. Iverson, J. D. Adams Mfg. Co.; E. F. Norelius, Allis-Chalmers Mfg. Co.; C. G. A. Rosen, Caterpillar Tractor Co.; Chairman J. W. Bridwell, Caterpillar; W. O. Beckman, International Harvester; A. F. Meyer, Jr., Heil Co.; L. E. Burgess, Mack Mfg. Corp.; Trevor Davidson, Bucyrus-Erie Co.; and R. C. Sackett, SAE staff

FOUR SPEAKERS who contributed to technical success of the conference, and three session chairmen: Right: R. F. Bourne and T. M. Fahnestock; Below, left: T. A. Haller, E. F. Norelius, and R. M. Schaefer; Below, right: D. K. Heiple and G. J. Storatz



Members of the SAE Student Chapter at University of Michigan visit Oldsmobile's "Rocket" engine plant at Lansing, Mich. This group is inspecting a 135-hp engine on test in the dynamometer test area. The tour of engine and final assembly plants followed luncheon in the Oldsmobile auditorium. Marshall McCuen of the engineering department delivered a paper on the "Rocket" in the morning

Describes Advances In Battery Design

• Northwest Section
Kenneth A. Short, Field Editor

April 7—Improvements in storage batteries have kept pace with the progress of the automotive industry, and the increased demands for capacity, reliability, and long life at moderate cost, have been so successfully met, that the hand crank is now of only historical interest. So said K. M. Ebert, vice-president and production manager of Laher Battery Products Corp., who stated by way of comparison that the battery of 30 years ago probably could not have started a present day engine on a cold morning.

Ebert gave an interesting resume of the experiments of Volta, Carlisle, Faraday, and Daniel, whose work resulted in the development of the primary battery, or dry cell, and proved of great help to Plante who, in 1860, demonstrated the secondary battery before the French Academy of Sciences. Planté's battery provided a source of relatively large currents, as compared to the primary cell, and opened the way for experiments by Fauré of France and Brush, in the United States, who independently conceived the idea of active materials derived from lead compounds, applied to metallic supports. From this time began the practical use of storage batteries, which gradually expanded until, in 1911, the advent of the electric starter put the battery industry in high gear.

The battery industry adheres largely to SAE standards for dimensions and electrical capacity, and methods of determining capacity. A standard for electrolyte strength and purity is maintained. The greater the impurities, the greater the rate of self discharge; hence, also, the need for filling with pure water. The "no overflow" type of filler has helped extend battery life.

A lead sleeve molded into the cell top with the post burned to it, has eliminated former leakage and looseness at this point. The need for hold down arrangements to eliminate vibration and side stresses was emphasized. Service men were cautioned to be sure of wire size and capacity, when replacing cables.

Pills for rejuvenating batteries were exposed as ineffective.

Ebert predicted the lead storage battery would be with us for some years to come, and said the much discussed nickel cadmium, while somewhat longer lived, is heavier, bulkier, and much more expensive than lead batteries of the same capacity. The world supply of these materials is not sufficient to make possible their general use for automotive purposes.

Officers of the Cal-Aero Student Club. Left to right: H. G. Moser, chairman; E. E. Mullen, vice-chairman; G. Strauss, secretary-treasurer; J. W. McKeehan, membership chairman; R. A. Rivero, publicity chairman; and R. W. Barrett, program chairman

Shaw Describes Speedway Perils

• Dayton Section
T. O. Mathues, Field Editor

April 5—Racing drivers are not half-witted daredevils but are highly skilled drivers who take a limited number of carefully calculated chances and prize their lives more than many Sunday drivers. So said Wilbur Shaw, president of the Indianapolis Speedway, speaking to Dayton Section members about the Memorial Day race.

He emphasized the importance of superb engineering in building a car to stand the grueling punishment and terrific pace of this classic race. When an unnatural noise develops in an engine turning almost 7000 rpm, he pointed out, there may be a hole in the block large enough for a small dog to jump through before the car can be stopped.

Shaw expects this year's race to be one of the fastest ever run, with qualifying time nearly 134 mph. Several diesel-powered cars may be entered for the first time. As yet, he said, no specifications have been set for turbine-powered automobiles.

Two Speakers Discuss Diesels, Crop Improvement

• Southern California Section
R. E. Strasser, Field Editor

March 23—The vital role of the diesel engine in making possible our high standard of living was emphasized at this meeting by D. A. Palmiter, engineering sales manager of Shepherd Tractor & Equipment Co.

He emphasized the extensive prog-

ress made since the days of 100-lb-per-hp diesels, when speeds of 100 to 400 rpm were accepted. Today engines of 400 to 650 rpm are considered slow.

How crop production can be increased by submerging the exhaust of an internal combustion engine in the irrigation water was explained by A. N. Anderson. The vice-president of Anderson-O'Brien Co. said that much of the soil in the arid regions of the western states is alkaline; mixing exhaust gas with the water forms a mild carbonic acid that neutralizes the alkali in the water. Even more efficient is a special carbon dioxide absorber with about 30% efficiency.

Anderson described a new device for keeping standby power in condition. It automatically starts the engine three times a week, runs it for ten minutes and shuts it down. The running is recorded on a graph that revolves once every 30 days, and service men are relieved of much maintenance.

Past-President Sparrow Speaks at Philadelphia

• Philadelphia Section
G. B. Calkins, Field Editor

March 8—Neither Studebaker's present engines, nor their "honorable ancestors," drew an unseemly display of reverence from SAE past-President **Stanwood W. Sparrow** as he illuminated the almost-human nature of any hard-driven, well-loved machine in his popular talk, "My Friend, The Engine."

The Studebaker executive showed a capacity audience how the aches and pains of developing a new power plant can be soothed by a sort of common-sense-of-humor, applied with care to the affected areas.

Sparrowisms in this category:

"Frontal area is easily measured by the size of the hole in the garage door if you forget to open it."

"Fans are like humans—easy to get to do things, but not without making a noise about it."

"One law that engine designers would like to see repealed: two bodies can't occupy the same space at the same time."

"Bearing load polar diagrams are useful for showing to visitors in the laboratory."

"The hydrogen bomb won't affect oil consumption, but almost everything else does."

"Friction shares the popularity of death and taxes, and is just as hard to do anything about."

"It's a wonder the exhaust pipe ever does get to the rear of the car!"

While Sparrow convinced his audience that the Champion's tail-pipe was,

25 Years Ago

Facts and Opinions from SAE Journal of June, 1925

Capt. E. V. Rickenbacker, vice-president, Rickenbacker Motor Co., visualizing conditions 25 years hence, predicted lighter - than - air craft (5000 ft in length) will remain in the air and in motion around the world without landing for a year at a time. Heavier-than-air craft will be utilized, he said, on feeder lines to the principal cities where dirigibles will serve as lighters to carry relief crews, passengers, rations, and equipment to the liners as they approach the main centers.

■

A. G. Herreshoff described to the Milwaukee Section how steam cooling accomplished the result of reducing friction loss by keeping cylinder walls and oil film at a high temperature and consequently keeping down the viscosity of the oil on the rubbing surfaces.

■

At a Metropolitan Section meeting it was suggested that better lighting of the roadway ahead of the car might be obtained by mounting the lamps in some other manner of place as, for instance, on top of the car or underneath the front axle.

■

Indiana Section held a Silver Anniversary Welcoming Dinner on May 29 as a tribute to accomplishments of the automotive engineer. Speakers included Charles M. Schwab, ex-Senator Albert J. Beveridge, Major-Gen. Mason M. Patrick and C. F. Kettering. F. E. Moscovics was toastmaster.

■

Voltage regulation is the latest development in the electrical control of an automotive generating system, Dale S. Cole said in a Milwaukee Section paper.

■

Because the Government is practically the only purchaser of aircraft, the Aeronautic Division has decided as a definite policy to propose as SAE Recommended Practices such standards as are adopted by the Joint Army-Navy Air Service Conferences.

■

When SAE Iron & Steel Specifications were revised in 1923, definite compositions for molybdenum steels could not be recommended because neither Division members nor the industry in general had sufficient experience on which to base any final conclusions.

■

A large increase in use of superchargers on racing cars has occurred during the last year, David Gregg says, and many important events in the United States and foreign countries have been won by them.

■

Discussion of paper on automotive air brakes by H. H. Hukill:

Question: What would be the weight of airbrake mechanism for a 4-wheel-brake car weighing 2500 lb?

Mr. Hukill: Total weight, with accumulator, would be between 50 and 60 lb, depending on the special levers and brackets required to connect into the brake linkage on the car. If a 3-cu-ft air-compressor were included, the total would be increased about 25 lb.

■

A paper by L. M. Woolson describes two new Packard aircraft engines, which compared with previous engines "are more compact and produce more power per pound of weight." Model 1500 develops 100 hp more than the Liberty engine while weighing 140 lb less; Model 2500 develops 250 hp more than its predecessor and weighs 75 lb less.

■

Three remedies for wheel-shimmy recommended by O. M. Burkhardt, Pierce-Arrow Motor Car Co. are: (1) design so no slakness can develop; (2) design for rigidity; (3) use effective devices to absorb kinetic energy wherever it is likely to accumulate.

■

To avoid shimmy with balloon tires, J. W. White, Wire Wheel Corp. of America, recommends that (1) all blacklash must be taken out of the steering mechanism; (2) all rake of the king-pin outward leading of the wheels and toe-in should be eliminated as far as possible. He suggests an hydraulic steering gear.

■

Discussion of paper on engine vibration by C. E. Summers, General Motors Research Corp.:

Question: Is any practical commercial method available for bringing an engine into perfect balance?

Mr. Summers: Engines that are not inherently out of balance may be brought into perfect practical balance by dynamically balancing all rotating parts and making all corresponding reciprocating parts of equal weight. An engine so balanced, however, may have torsional vibration of the crankshaft, since this results from elasticity rather than from balance.

in fact, persuaded to occupy the normal position, he also made it clear that a designer's problems are not all of the kind which succumb to higher mathematics alone.

Britain Manages Well On Lower Grade Fuel

• New England Section
Arnold R. Okuro, Field Editor

April 4—**George A. Round,** chief automotive engineer of Socony-Vacuum Oil Co., Inc., was on hand at this meeting to report experiences and observations on a recent tour of vehicle manufacturers, fleets and refineries in England, Scotland, Denmark, Sweden, and Italy. His talk was illustrated with excellent color slides as well as slides and pictures dealing with technical features of European equipment.

Gasoline in England, he said, is severely rationed, heavily taxed, and not used by trucks or buses in commercial transportation. Significant in the operation of 7000 vehicles of the London Transport was a complete absence of smoke or odor on acceleration—attributed by Round to a demand for clean combustion realized by careful design engineering to improve turbulence in the combustion space.

Although these engines use a comparatively low grade of fuel with considerable sulfur content, power output and economy are superior and burned fuel residue negligible. Open combustion chamber design with masked valves, "squish" pistons, and a rigid maintenance schedule results in unusual efficiency.

High costs, he said, have caused people in the countries he visited to turn to bicycles, motor scooters, and small cars for private transportation.

Formulas Evaluate Truck Performance

• Philadelphia Section
C. B. Calkins, Field Editor

April 12—An easy and accurate method of computing truck performance was described at this meeting by **Carl Saal,** highway engineer for the Public Roads Administration, who called attention to two SAE papers that stemmed from the work of the SAE Subcommittee on Classification and Evaluation of Transportation Engineering Formulas: "A Method of Predicting Road Performance of Commercial Vehicles," by A. F. Stamm and E. P. Lamb, and his own "An Evaluation of Factors Used to Compute Truck Performance," presented two years ago.

Top speed and grade ability data from recent tests, he said, indicate that theoretical factors employed in the method come close to permitting armchair predictions of commercial vehicle performance. Saal drew his experimental results from a study by the Highway Research Board. Seven test vehicles, ranging from a 2-axle single-unit truck to a 7-axle tractor/semi-trailer/full-trailer combination were operated on the level and on 3, 6, and 8% grades.

Basic Data Needed

For the computations, certain basic information is required, including: engine power versus speed characteristics, gear ratios, vehicle gross weight and frontal area, tire size, and road surface condition and altitude.

While the theory is sound, Saal pointed out, computed results can be no better than the various constants employed, and thus cannot fit each individual vehicle perfectly. If exact data are desired, actual road tests continue to be the answer.

Predicts Greater Use Of Aircooled Engines

• Mohawk-Hudson Group
Frank Baker, Field Editor

March 29—Mohawk-Hudson Group members joined SAE Student Branch members from Rensselaer Polytechnic Institute on the RPI campus to hear **Carl F. Bachle,** vice-president in charge of research for Continental Aviation and Engineering Corp., speak on "Aircooled Engines for Vehicles."

Since he first worked on this kind of automotive engine in 1932, Bachle said, research in cooling, metallurgy, fuels and combustion has resulted in development of an aircooled engine that can soon compete with and partially replace the conventional liquid-cooled engine.

Performance of these engines, he said, is limited only by the ability of the cooling fan to perform efficiently. Power required to drive the fan is about 5% of the engine output. For any given cooling requirements, the horsepower of an aircooled engine is between one-half and one-third that required by a cast iron liquid-cooled engine. This is partly because of temperature differential between cylinder and cooling medium, and specific heats of the metals involved.

Bachle predicted a hopeful future for these units in heavy-duty trucks, buses and tractors. Its weight advantage (one-third the weight of a water-cooled engine) makes it attractive to fleet operators who can haul more payload with the same power, and also enhances the possibility of rear-engine pleasure vehicles, since the rear axle will not have such a heavy overhung load to contend with.

Three Experts Advise Student Engineers

• Central Illinois Section
Ivan Lamport—Field Editor

March 20 — Engineers who want to "Grow in Engineering" received a great many worthwhile pointers from the three speakers at this meeting.

Robert Fletcher of Hyster Co. told the group they must:

1—Decide upon their objective in life
2—Get all the facts about what will be requested of them
3—Group these facts in a logical but flexible plan
4—Make a timetable for their plan
5—Concentrate on one step at a time
6—Keep their objectives clear.

One way to really keep sharp, Fletcher said, was to teach fundamental technical courses as "extra-curricular" activity. "There is no better way to learn a subject," he said, "than to teach it."

Certain fields in industry are putting emphasis (as well as higher pay) on advanced degrees, he said, and graduate work is then well worth the extra effort.

Engineers Like Aladdin

C. G. A. Rosen of Caterpillar Tractor Co., the second speaker, likened engineers to Aladdins whose magic wands had swept the great fleets of sailing ships from the seas, and replaced them by Diesel motor freighters. The ideal engineer, he said, is a man of many facets. A classic example was the medieval Florentine genius Leonardo da Vinci. Rosen said he was sure if da Vinci were here he would tell us to "Seek ye ever the knowledge of fundamentals and all these other attributes will be added thereto." These fundamentals are, he said:

1—The constant discipline of the mind
2—The enthusiastic will to serve.

Outstanding examples today of people who apply these fundamentals to their lives are Donald McLaughlin, president of a large British mining syndicate, Haraden Pratt, vice president of International Telephone and

Telegraph, "Boss" Kettering, Den Hartog, Bob Russell, head of Research for Standard Oil of New Jersey's Esso Laboratories and Prof. William Durant of Stanford University.

Next **George Downing** of the educational committee of General Electric Co. said when the young engineer graduates from college he faces two important problems:

1—What kind of engineering work should I get into;
2—How can I further train in order that I may advance in job or income.

General Electric tries to help solve the first problem by using a planned program (for the first two or three years) of rotating assignments, where the young engineer may gain practical experience, and get to know intimately the many phases of company activities. Along with his shop work he also gets classroom instructions on business principles, accounting, credit, advertising, business functions, earnings, engineering principles and application.

General Electric Program

When he selects a specific field to specialize in, post-graduate courses are available for him through competitive examinations. These fields are—sales engineering, advanced engineering, creative engineering, and manufacturing engineering. By these methods G. E. hopes to eliminate oval pegs in round holes, which results, Downing said in personal happiness and maximum chance for advancement to the young engineers.

During the discussion that followed, a young engineering instructor asked how he might instill in his students the desire, and impress on them the necessity, of learning fundamentals. Most engineering students, it seems, would much rather memorize a formula than try to understand basic fundamentals. This question was answered from the floor by an engineer who advised the instructor to have his students get jobs as bill collectors during the summer vacation. From his own experience, a few weeks of punching doorbells, and getting punched in the nose, he said, would make the student glad to learn the fundamentals and be a good engineer so that he wouldn't ever have to do that again.

Experience Problems

A bewildered student asked how he might get experience so that he might get a job. It seems this student was job hunting and everyone always asked how much experience he had. It seemed to him that everyone wanted to hire people with lots of experience and no education, and all he had was lots of education and no experience. Downing replied that his company (G.E.) looked first for C.P.A. (This, he said, means Character, Personality, and Ability) and not for experience.

Robert Larson, Staff Engineer, Caterpillar Tractor Co., was meeting chairman.

STUDENT NEWS

California State Polytechnic College

A demonstration of the new supersonic, low-density wind tunnel was the object of a field trip to Berkeley made by 25 SAE Enrolled Students on April 4. They learned that the tunnel is a continuous flow type that holds velocity constant with steam ejectors connected in series.

Moving at a velocity of Mach 2.7, the airstream (largely nitrogen) showed visible shock waves on a test specimen placed in the throat section. Shock waves could be seen by the afterglow of the nitrogen. Density is so low that the mean free path (the average distance through which a molecule can move between two successive collisions) is about 23 ft.

Northern California Section members were hosts at dinner, and awarded prizes to five student speakers. G. Greene of University of Santa Clara was first prize winner with "Titanium—The Wonder Metal." Second prize went to E. E. Arnosti, Stanford University. Tied for third place were R. Richardson, California State Polytechnic College; T. R. Carrell, University of California; and C. E. Hirsch, Stanford.

On April 13, the Cal Poly Student Chapter met with the college chapter of the Institute of the Aeronautical Sciences. Two students from each student chapter spoke. L. C. Quigg and A. C. Lee of IAS spoke on "Metal Spars" and "Advancement of Aircraft Cabin Pressurizing" SAE Students A. Morrison and F. E. Pilling reported on "Inspection of Rotating Cutters" and "Alcohol Injection." Morrison constructed a portable stroboscope capable of inspecting rotating cutters for poor finishes, and so forth. Pilling designed and constructed a successful alcohol injection carburetor.

After the talks, students saw two films—"A Thunderbolt is Made" and "Ground Handling of the P-47."

Phillip B. Garner

Northrop Aeronautical Institute

Speaker at Northrop's recent combined SAE and IAS dinner meeting not only holds the world's speed record for flight at near sea level alti-

tudes, but was also responsible for a record attendance at this meeting.

Gene May, Douglas test pilot, emphasized the importance of the engineer's job in the aviation industry, and cited the fact that he is still alive after almost 25 years of flying as proof that engineers have done their job well.

Much of May's talk was devoted to flight testing of the Skystreak and Skyrocket. During his first nine hours of flight in the Skystreak, which he piloted on its maiden flight, the plane broke two speed records, and appeared to need only one change—substitution of a laminated plate glass canopy for the original of plexiglass. The Skyrocket is even faster, but there are no public figures.

According to May, the so-called sonic barrier, long believed to be a kind of stone wall reached at Mach 1, does not exist in that form at all. The barrier is a function of power, and can be designed into or out of the airplane. In the case of the Skyrocket, it was designed out. Describing the Skyrocket's flight from subsonic to supersonic speed, May said:

"As the speed of sound was approached, the only phenomenon that occurred was a slight roll of the aircraft to the left. As correction was made for the roll, the airplane oscillated gently about three times, and by the time the necessary trim was made, the speed of sound was exceeded. The immediate occurrence is quietness, with only the noise originating in the cockpit being heard by the pilot."

He said the Skyrocket is the only existing airplane yet capable of supersonic speeds at all flyable altitudes.

—Joseph Toth and W. J. Poppe

Lawrence Institute of Technology

Ford's River Rouge plant was the scene of an L.I.T. Student Branch tour, April 21, that started with a bus trip around the plant's 1196 acres and ended with a visit to the glass plant. Members saw blast furnaces, docks, assembly buildings, machine shops, paper mills, the glass plant, and the Ford coke ovens.

At the asembly plant the frame is started down the line and motor and steering post quickly installed. Next the body is lowered into place and seats, flooring, hood and bumpers put on. At the end of the line, cars are driven away at the rate of 63 an hour.

The press steel building has two-story presses that turn flat sheets of steel into Ford tops, hoods, and body sections. Hundreds of smaller presses turn out gas tanks and the many braces needed to complete the automobile body.

Glass is poured in the glass plant at the rate of 14 fpm from a furnace that can produce 115 tons of glass every 24 hr. The glass is rolled out, ground with large sand wheels, and polished with a rouge compound. Safety glass plastic is baked between sheets and the glass is cut to size for the body assembly.

—Court Holliday, Field Editor

Cal-Aero Technical Institute

Wallace Linville, formerly of General Petroleum Corp., was speaker at this Student Branch's first general meeting on March 17. After showing a film of the detonation and combustion cycle in a single cylinder of a gasoline engine, taken partly at 5000 frames per sec, Linville explained the different oils, paraffinic and naphthenic, with the aid of yellow and black rubber spheres representing molecules and their structures. He explained their uses, mentioning that fluidity of paraffinic oils is superior to that of naphthenic oils under extreme temperature conditions, and that paraffinic oils can be manufactured more easily than naphthenic. But naphthenic oils are being used more and more for heavy-duty and

diesel engines as new chemical means of processing are developed.

Linville demonstrated combustion and detonation action by igniting gasoline vapor in a long 24-in. glass tube. By stopping up one end, he was able to build up pressure as the flame traveled the length of the tube, and thus demonstrate pre-ignition, or knock.

—R. A. Rivero

Oklahoma A & M College

SAE Enrolled Students at the April 13 meeting in Stillwater heard all about modern mass production methods for reconditioning parts. Speaker Lewis A. Lee, manager of the Fred Jones Mfg. Co. of Oklahoma City brought with him reconditioned parts ranging from water pumps to complete engines.

He emphasized careful attention given not only to clearances and tolerances but to such details as which surfaces are left unpainted and why. Many short cuts used in making cheaper rebuilt parts were shown—especially those used for clutch and clutch pressure plates.

The many operations performed on a reconditioned engine include reboring, honing, and regrinding of crankshafts. Every reconditioned part is first given an operation test and each engine run under its own power.

—Harvey F. Dick, Field Editor

Chrysler Institute of Engineering

Student Chapter members at the April 13 meeting saw two films—one on "How Industry Uses Rubber," and another on one of the latest developments in the tire industry, "The B. F. Goodrich Tubeless Puncture-Sealing Tire." Leo Gibbons, manager of the automotive section of the company, told of the importance and antiquity of the rubber industry and of his own experiences since the days of fitting tires to horse-drawn vehicles.

Bradley University

Members of the SAE Student Club at Bradley heard James C. Porter, Central Illinois Section secretary, speak at their March 7 meeting on "Alcohol Water Injection for High Compression Engines."

Porter, who is with the U. S. Department of Agriculture, brought along two assemblies of alcohol water injectors, one bought commercially and the other built at the Department's Northern Regional Research Laboratory where he is employed, so that the students could see them completely disassembled.

Porter said that even for compression ratios considerably beyond the present range, a good grade of present-day premium gasoline in combination with alcohol-water injection would give knock-free performance. This is true of tractor, truck, and automobile engines.

Specified octane requirements of all cars are not satisfied by premium fuels, he said. Percentage varies with the particular section of the country. In many cases, spark setting may be retarded with only a slight reduction of performance; however, alcohol-water injection would permit maximum power spark advance.

Parks College of Aeronautical Technology

Eighty-four members of the Parks SAE Student Branch and their guests heard R. M. Dunn, director of engineering and maintenance for Trans World Airline, speak at their February 23 annual banquet.

Engineering departments, Dunn said, want graduates to know more about the component parts of a plane than the manufacturer does. Three things his organization considers important are a sound basic knowledge of the industry; ability to think analytically and critically, and lots of plain horse sense.

Sodium Sulfite

Continued from p. 73

clone separator to minimize entrainment of water with the gas. Exhaust gases entered through the vertical leg of an L-shaped 4-in. pipe. The submerged section of the pipe paralleled the bottom of the scrubber and emitted the gas through ten 1-in. diameter holes. From the scrubber, gas passed through a packed tower where traces of entrained water were removed, so that they would not interfere with measurement of the aldehydes in the outlet gas.

Approximately 10 gal of the scrubbing solution removed more than 90% of the aldehydes for approximately 12 hr at a scrubbing temperature of 133 F. During this period, approximately 45,000 cu ft of dry exhaust gas (at 60 F and 29.92 in. Hg) containing an average of about 15 parts of aldehydes per million parts of exhaust gas was scrubbed.

The method is economical as well as effective. Cost of scrubbing chemicals for an engine producing 500 cu ft per hr of dry exhaust gas and operating 8 hr per day is estimated at about 80¢ per day. (Paper "The Composition of Diesel Exhaust Gas" was presented at SAE National Diesel Engine Meeting, St. Louis, Mo., Nov. 2, 1949. This paper is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Index Rates "Scarcity" of Scarce Materials

Based on paper by

JERARD M. PEDERSON

General Electric Co.

HIGH-TEMPERATURE alloys, gas turbine engine components, and even whole engines containing elements in critically short supply can be rated objectively on their relative criticalness.

Such evaluation can aid in programs aimed at reducing use of highly critical materials by substituting less critical or noncritical materials. The evaluation can be made this way:

1. Give each scarce element used an index number according to its scarcity relative to that of a base element. For example, if the scarcity of nickel is rated as 1, and tungsten is 10 times as scarce, cobalt 15 times, columbium 20 times, and chromium only 5 times as scarce, element index numbers are:

nickel	1
tungsten	10
cobalt	15
columbium	20
chromium	5

2. Compute alloy index numbers by summing the products of the per cent content of each critical element and its index number. In the case of turbine bucket alloy S816, which requires the scarce elements listed in Step. 1, the summation is:

Ni	20 × 1	20
W	4 × 10	40
Co	38 × 15	570
Cb	4 × 20	80
Cr	20 × 5	100
Alloy Index Number		810

3. Compute component index numbers by multiplying the weight of the alloy used by its alloy index number. Engine parts that require considerable

amounts of the more critical elements will stand out. Their high index numbers can guide establishment of priorities for development effort.

4. Sum component index numbers to find the engine index number.

Of course, this comparison does not take into consideration differences in component life or engine life. If life expectancy can be established by test, component index numbers or engine index numbers multiplied by hours of life give a more accurate picture of relative merit.

Advances in design techniques can lead to reduction in index numbers without sacrifice of life or performance. But in general, decreases in index numbers, and therefore in use of critical materials, entail decreases in life or in performance due to redesign to ease operating conditions. (Paper "Reduction in the Use of Strategic Materials in Turbojets" was presented at SAE Annual Meeting, Detroit, Jan. 12, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Tells How Engine Converts Fuel Energy

Based on paper by

PROF. W. E. LAY

University of Michigan

THE conversion of fuel energy into power by the internal combustion engine is explained in a step-by-step analysis by Prof. Lay in his paper.

He starts with a fundamental exposition of the concept of power. The expression for power, he notes, is made up of an independently variable intensity factor and an independently variable flow rate factor. Next step is a discussion of how fuel constituents and air combine chemically to release heat energy. Heat quantities released in combination of various hydrocarbons are given.

A review of factors entering into volumetric and thermal efficiencies follows, with expressions for each presented. Prof. Lay then derives formulas for computing power delivered by both supercharged and normally aspirated engines. He gives two examples to show how power calculations can be made. (Paper "Elements of Internal Combustion Power," was presented at SAE National Passenger Car, Body, and Production Meeting, Detroit, March 15, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

About SAE Members

Continued from p. 79

RICHARD B. BOOTH, formerly a student at Northrop Aero Institute, is employed by the North American Aviation Co., Inglewood, Calif. as an enginering draftsman.

ROBERT LEE FORBES, a former student at Northrop Aeronautical Institute, is an engineering draftsman

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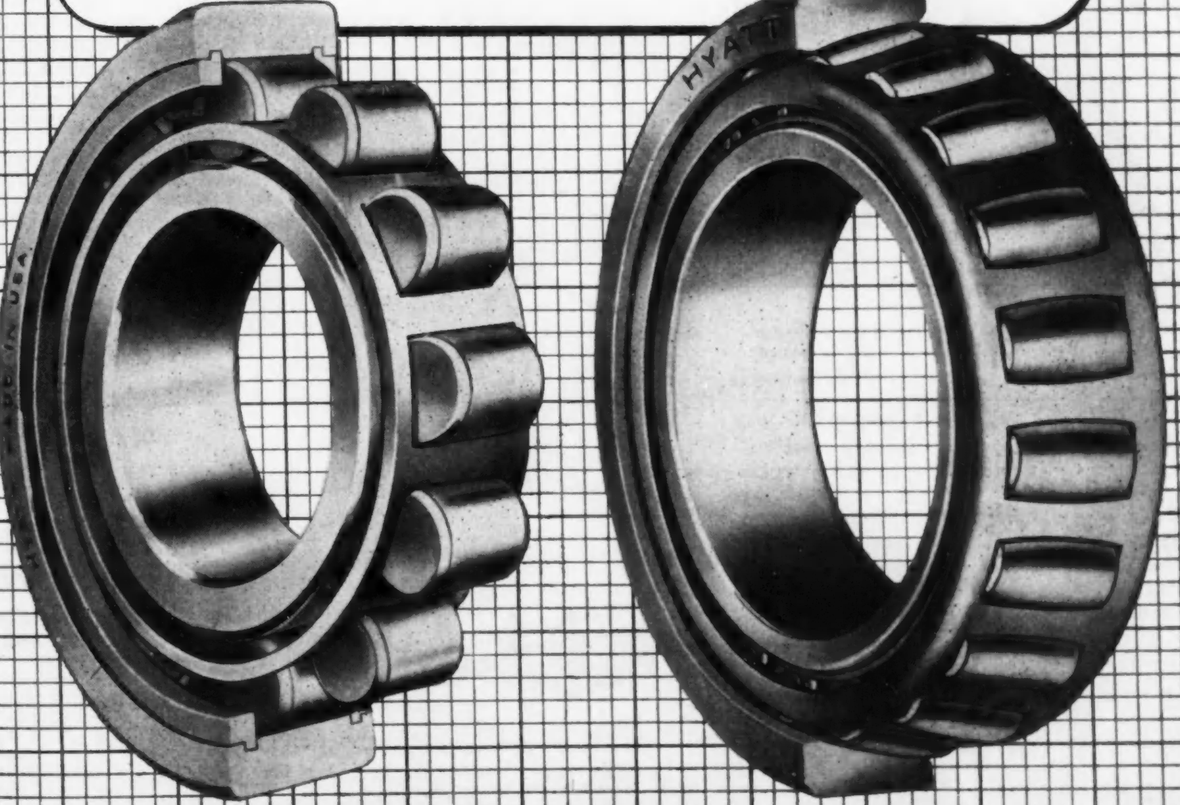

HYATT ROLLER BEARINGS

with Beech Aircraft Corp., Wichita, Kans.

OTIS W. MARSHALL, JR. has accepted a position with Curtiss-Wright Corp., propeller division, Caldwell, N. J. in the rocket research department.

ROBERT H. ROSS, a recent graduate of the University of Colorado, is with Westinghouse Electric Corp., East Pittsburgh, Pa. as a graduate student.

ROBERT ULLMAN, formerly with the Chevrolet Motor Division of General Motors Corp., Detroit, Mich., is now a designer for Aircraft Marine Products, Inc., Harrisburg, Pa.

HAROLD O. HOLZ is now a senior layout draftsman with Harry Ferguson, Inc., Detroit, Mich. He was formerly an assistant engineer for the Allis-Chalmers Mfg. Co., Milwaukee, Wis.

EDWIN L. FISHER, who was formerly employed by Fairbanks, Morse & Co., Beloit, Wis. as a process engineer, is now a design engineer with the Kohler Co., Kohler, Wis.

MILTON F. BAKER is presently employed by the Earp Sound and Equipment Co., Oklahoma City, Okla. as a technical adviser.

RAYMOND M. DOST is now a junior petroleum engineer with the Stanolind Oil and Gas Co., Ft. Worth, Tex. He was formerly employed by the same company in the Lubbock District Office, Lubbock, Tex.

HERBERT K. SACHS, formerly employed as a lay-out draftsman for American Car and Foundry, Berwick, Pa., now holds a similar position with the International Harvester Co., Fort Wayne, Ind.

ALFRED W. WANDSCHNEIDER is now employed by the Durez Plastics and Chemicals Co., North Tonawanda, N. Y. as a trainee in the sales service department.

KENNETH E. SCHLUNDT, formerly a student at Tri-State College is now with Deere and Co., Moline, Ill. as an engineering draftsman.

ROBERT M. SHOEMAKER, a recent graduate of the University of Illinois, is now connected with the Kellogg Switchboard and Supply Co., Chicago, as a salesman.

ROBERT GORDON MacEWAN, who graduated from the University of Michigan in February, is now employed by the Allison Division of General Motors Corp., Indianapolis, Ind. as a test engineer.

T. GARDNER HILL is now self-employed as a practicing professional design engineer at Fort Myers Beach, Fla. He was a designer for Glenn L. Martin Co.

Applications Received

The applications for membership received between April 10, 1950 and May 10, 1950 are listed below.

Atlanta Group

Carl R. Allen.

Baltimore Section

Harld B. Isennock.

British Columbia Section

Basil V. French, Robert Edwin Williams.

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Buffalo Section

Robert William Loyd, Jr., Albert L. Miller.

Canadian Section

Jack D. Cape, A. Albert Cousineau, George Galloway, G. Hampson, Robert Norman Lindley, John Tennant Panks, Duncan Cameron Quin, Harold William Royl, John Charles Tew, Robert John Whitla.

Central Illinois Section

Wendell T. Barber, Lawrence F. Fratzke.

Chicago Section

George A. Becker, Joseph J. Clark, Melvin E. Cowden, Henry Anthony Ferguson, Earle D. Haley, Jr., Nicholas L. Heinz, Theodore B. Keller, R. Donald Pinkerton, Irving Earl Schaumberg, Edwin C. Sittler, Don F. Stranberg, Joseph S. Tinaglia, Lewis Woolsey.

Cleveland Section

Jay Wolfert Atman, Siddhavaram Lakshmi Balasubramanyam, Herbert Elmer Cissley, Hans E. Fueger, Clarence John Parker, Jr., Robert F. Tillman.

Dayton Section

William B. Boyd.

Detroit Section

Carl E. Bergen, W. O. Briggs, Jr., Alfred M. Cordes, John B. Craft, Henry C. Daum, David J. Dunlop, Kenneth W. Gage, Robert Harper Garmezy, Robert C. Glasson, E. L. Harrig, Fred W. Kelsey, Robert D. Kemp, John E. Landino, D. F. Lemaux, J. R. Mahan, I. C. McKechnie, Howard Allen Peterson, Fred H. Race, Edward F. Reynolds, Martinus Ris, Jr., William D. Singleton, Walter C. Skuce, Sheldon J. Stanaway, Philip W. Tabb, Andy Torok, Raplh Underdahl, Harold R. Underwood, John F. Verkerke, John Zytkewick.

Hawaii Section

Arthur N. W. Andrews, Joseph O. Pueschel.

Indiana Section

Gale Rolland Beardsley, Xerrex Y. Cox, Samuel G. Johnson, Carl H. Toedtmann.

Metropolitan Section

Jean A. Aguer, Russel J. Allen, Al Anderson, Edward D. Bradey, Leo R. Dixon, Edward M. Doyle, Louis W. Eppel, Eugene T. Ferraro, Scott Flower, Chester J. Flynn, Max R. Franquemont, Bernard Goldman, Albert Malek, George R. Mathews, Rosario O. Negri, Frank J. Osorno, Jr., Lars-Georg Romberg.

Milwaukee Section

William Waller Carson, Donald R. MacLeod, Robert Ellis Perlewitz, James W. Reetz, William Albert Staats.

Mohawk-Hudson Group

Charles O. McCumber.

New England Section

Joseph R. Comeau, Edwin F. Delany, Hans A. Hug, John William Jacobsen, Cramer W. LaPierre.

Northern California Section

Charles E. Hirsch.

Northwest Section

Robert H. Huestis.

Oregon Section

Morris C. Anderson, Earl M. Kruger.

Philadelphia Section

William F. Ball, Jr., Merwyn F. Prior.

Continued on p. 103

Pittsburgh Section

William J. Atwell, William J. Kysar.

St. Louis Section

James B. Irwin.

Southern New England Section

John C. Lane.

Southern California Section

Howard Allen Peterson, D. W. Anderson, Edgar B. Arnold, Gustavus B. Pearson, Wilmot Sandham, Robert Wesley Suggs, Jr., Versile H. Stewart.

Syracuse Section

Harold Edwards.

Texas Section

Charles Emil Swenson.

Twin City Section

Edward B. Brenan, Albert W. Yates.

Washington Section

Leo Stanley Crane, Jerrold Fletcher Finch, Charles H. Ruth, Jr.

Outside of Section Territory

Alfredo I. Christlieb, William L. Cook, James Ernest Couvillion, Frank DeFrance, Alexander Havelock, Thomas H. Morrell, J. Rice Shellabarger, Major Walter Byrd Wilson, Jr.

Foreign

Major U. S. Amn, India; Lt-Col. Satish Chandra Ghosal, India; Peter Hawtrey Mainprize, England; Hassen Mariy, Egypt; Olle Schjolin, England; Leonard Taylor, England.

New Members Qualified

These applicants qualified for admission to the Society between April 10, 1950 and May 10, 1950. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Baltimore Section

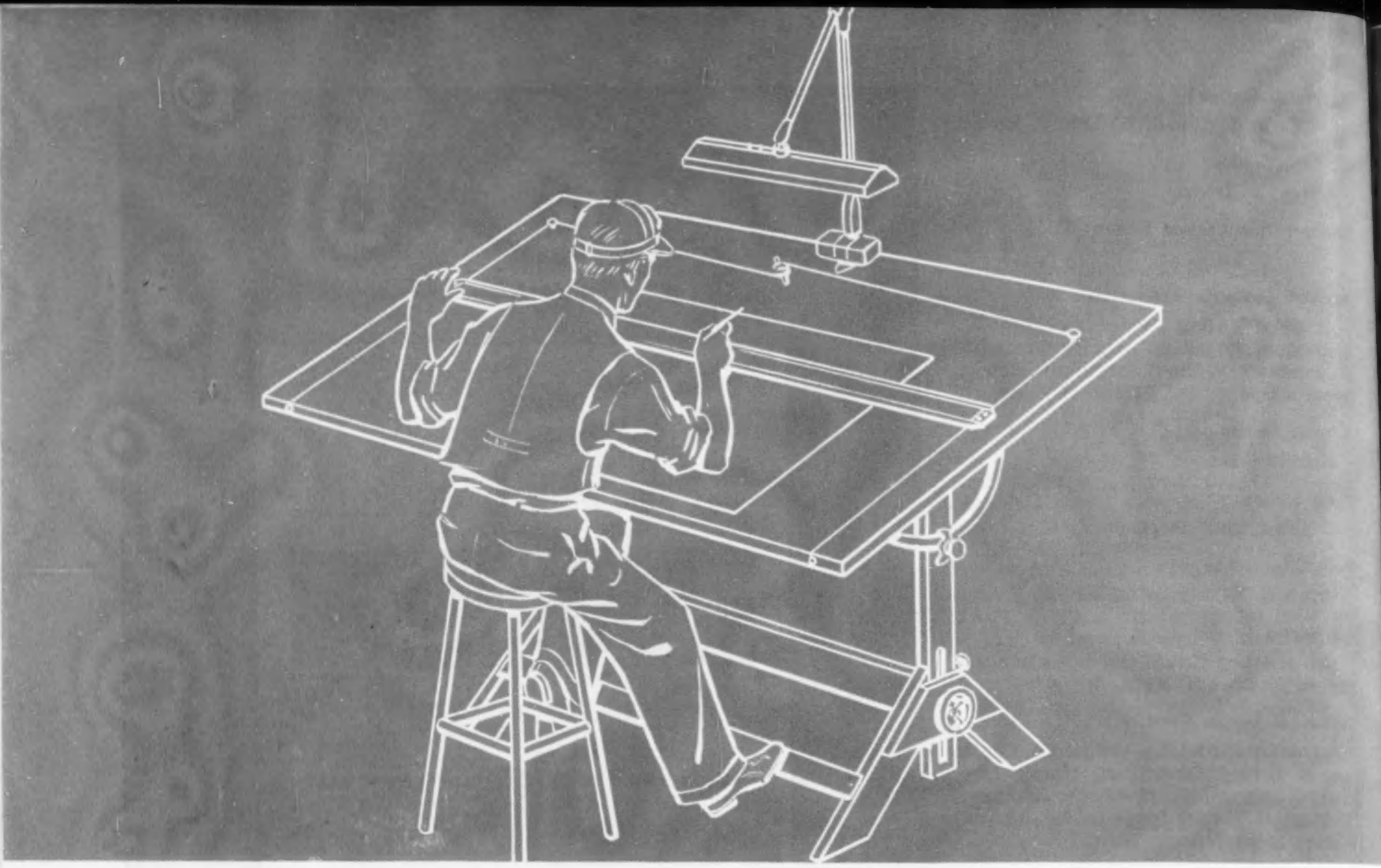
Delbert E. Fetterolf (M), Valentine F. Pabst (A), Albert Theodore Woollens (M).

British Columbia Section

Cecil G. Trotter (M).

Canadian Section

H. L. Barre (A), J. Don Ferguson (A), James E. Gordon (A), Alfred L. Hay (A), E. G. Jennings (A), David



Kaufman (M), Thomas Leonard Orford (A), Donald H. Storey (J).

Central Illinois Section

John E. Griner (J), Edward H. Leavitt (J).

Chicago Section

Roy B. Bender (M), John D. Cannady (A), Hurley Dean Cook (J), Julius Hezler, Jr. (M), David H. Holmgren, Jr. (J), Robert Joseph Kocek (J), H. A. Land (M), Hollis B. Letson (A), Bernard Yale McCarty (M), Charles Richard Racine (A), John A. Scudder (J), Frank Owen Tallman (A), Donald Charles Walker (J), Alvin P. Williams, Jr. (J).

Cincinnati Section

Arthur J. Carroll (A), Leon L. Kuempel (M).

Cleveland Section

Walter W. Bulgrin (M), K. Stanley Hawkins (SM), Otis Emery Herweg (M), Richard Louis Riedel (J), Harold R. Smiley (J), Robert W. Underwood (M).

Colorado Group

Rollin Ford Allyne (M).

Dayton Section

Truman Gray Foster (J), E. C. Harriman (A), Roger M. McClung (J), George Miliziano (J), William T. Reid (M), John L. Roberts (J).

Detroit Section

Robert Lynch Allen (M), John Wenner Applin (J), Alvin H. Bauman, Jr. (J), Garvin Bawden, Jr. (A), George Bennett (M), Walter Joseph Bielawski (J), Harry Bowering (A), Sam Dabich (J), Ralph L. Darch (A), Edward R. Davies (M), Dorman B. Dickerson, Jr. (M), A. H. Esper (M), William Clay Ford (A), Karl M. Greiner (A), Harry Harlow (M), Gordon W. Harry (M), John E. Hilton (J), Victor Hopeman (M), Clevoe D. Jones (A), Zbigniew Joseph Karczewski (M), James G. Kennedy (A), Herbert H. Kietzer (M), Stanley A. Kostrzewa (A), Waldemar R. Kotoucek (M), Gordon J. LeBrasse (M), Arthur H. Lieder (J), Benard L. Maas, Jr. (A), Richard L. Merrell (J), William David Morcom (A), Arthur Pachulski (J), Willian E. Plummer (M), Arthur T. Porter (A), Eric O. Prange (A), Horace Prunk (A), Albert E. Samson (J), Frederick A. Scotton (M), Herbert M. Seeger (M), Theo F. Sharp (J), Roscoe M. Smith (M), Jess J. Somergary (J), Arthur H. Stahlhuth (M), Melvin Fredrick Sterner (M), Lonnie J. Thomas (J), Dale H. Tillotson (M), Lewis A. Tyner (M), C. James Warner (A), Eldon C. Warner (J), Earle D. Williams (M).

Indiana Section

Raymond H. Cowles (M), Paul E. Hitch (M), Roy M. Porter (M).

Kansas City Section

Norman R. Parmet (J).

Metropolitan Section

Paul B. Alper (J), Eduard Baruch (A), Fred W. Berger (M), Charles Henry Brock, II (A), August C. Esenwein (M), Norman Gerald Froomkin (M), Karl H. Grassow (A), Gus Kaufman (M), Charles C. Kostan (J), Byron E. Mills (A), Saul Perlin (A), Quentin G. Pletsch (J).

Mid-Continent Section

Bert C. Frichot, Jr. (M), Robert W. Schuetz (J).

Milwaukee Section

Donald F. Bedard (J), Floyd Alfred Blake (J), Russell N. Booth (J), Gordon MacDonald Byrnes (M), Einar S. Dahl (M), Clarence S. Dahlgren (A), Melbourne Fischer (A), Louis C. Frank (M), Arthur G. Hall (M), Clifford Harvey Jensen (J), Henry Andruss

Martin, Jr. (J), Willian J, Prankratz (A), Frank Raymond Riedmueller (J), Steen Strand (M).

New England Section

Roy M. Barnes, Jr. (A), Sherman Guy Forbes, Jr. (M), John L. Hepperle (A).

Northern California Section

Sumner H. McAllister (M), Robert Angus McDonald (J), B. Clinton Merithew (J), Frank Morgan (A), Charles B. Wall (A).

Northwest Section

J. Norris Pearson, Jr. (J), Floyd R. Ritchie (A).

Oregon Section

Michael Petri (J), Charles A. Richmond (J), Fred W. Sparks (A).

Philadelphia Section

Ralph S. Anderson (J), Leon F. Dumont (J), Robert M. Ramey (M), Murray K. Simkins (M), Frank T. Zuch (J).

Pittsburgh Section

H. P. Hobert (M), Thomas J. Hutchison, Jr. (A).

Salt Lake Group

DeVon Crosby (A).

San Diego Section

Machlin B. Laddon (M).

Southern California Section

L. R. Baker (A), Frank C. Butch (A), Ilo S. Dellinger (A), Melvin Wiley Hall (J), Donald S. Marden (J), Reynolds J. Mitchell (J), Leo M. Shanahan (A), Gerald H. Smith (J), Robert E. Strasser (J), William Marmaduke Withrow (J).

Southern New England Section

Irving Twomey (M).

Syracuse Section

John E. Dahl (A).

Texas Section

Howe M. Carey (A), Richard C. Marr (M), James O. Quinn (A), Constantine M. Xeros (J).

Twin City Section

S. H. Knight (A), Louis C. Newton (M).

Washington Section

George Walter Dorr (A), Rear Admiral Alfred Melville Pride (SM).

Wichita Section

Cecil H. Gilliland (J), Henry W. Pfeifer (J).

Williamsport Group

Carmine Pinto (A).

Cities Outside of Section Territory

Richard Bayer (A), John H. Edman (M), Clyde L. Filkins (A), Kurt Gold-

mann (M), Heinz V. Menking (M), William P. Oehler (M), Vincent George Polovkas (J), Armin R. Reinert, Jr. (J), Capt. John Smith, Jr. (SM), Ernest von Kuschka (A), Edward C. Wood (M), W. Leland Zink (M).

Foreign

Attilio Bonesi (FM), Italy; Albert Coppens (FM), Belgium; Tilak Raj Lall (J), India; Reginald John Middleton (FM), England; Marcos B. Santos, Jr. (J), Brazil; Thomas Drayton Walshaw (FM), England.

HAVE YOU Changed Your Address?

So that your SAE mail will reach you with the least possible delay, please keep SAE Headquarters and the Secretary of your local Section or Group advised of any changes in your address. Such notices should be sent to:

1. Society of Automotive Engineers, Inc., 29 West 39th St., New York 18, N. Y.
2. The Secretary or Assistant Secretary of your Section or Group at the addresses listed below:

Baltimore

Ward L. Bennett, Baltimore Transfer Co., Monument & Dean Sts., Baltimore 2, Md.

British Columbia

Burdette Trout, Suite 6, 1436 Pendrill St., Vancouver, B. C., Can.

Buffalo

Robert W. Morgan, 32 Windover, Hamburg, N. Y.

Canadian

Frank G. King, Canadian Automotive Trade, MacLean-Hunter Publishing Co., Ltd., 481 University Ave., Toronto 2, Ont., Can.

Central Illinois

James C. Porter, 120 Isabel Ave., Peoria, Ill.

Chicago

Floyd E. Ertsman, Chicago Section, SAE, 1420 Fisher Bldg., 343 S. Dearborn St., Chicago 4.

Cincinnati

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Cleveland

(Miss) C. M. Hill, 7016 Euclid Ave., Cleveland 3, Ohio

Dayton

Fred Schwenk, Fred's Auto Hospital 1522 Xenia Ave., Dayton 10, Ohio

Detroit

(Mrs.) S. J. Duvall, Detroit Office SAE, 100 Farnsworth Ave., Detroit 2 Mich.

Hawaii

Fred Hedemann, 2110 A Kakela Pl., Honolulu, T. H.

Indiana

R. P. Atkinson, General Motors Corp., Indianapolis 6, Ind.

Kansas City

John P. Dranek, Box 304, Grandview, Mo.

Metropolitan

(Miss) J. A. McCormick, Society of Automotive Engineers, 29 West 39th St., New York 18, N. Y.

Mid-Continent

Delton R. Frey, 234 N. Highway, Route 2, Cushing, Okla.

Milwaukee

Charles H. Duquemin, Le Roi Co., 1706 S. 68th St., Milwaukee 14, Wis.

New England

Edward G. Moody, Ed. G. Moody & Son, Inc., Daniel Webster Highway, Box 130, Nashua, N. H.

Northern California

Morris H. Pomeroy, P. O. Box 427, Burlingame, Calif.

Northwest

Alfred P. Nelsen, Wagner Electric Corp., 1918 First Ave., S. Seattle 4, Wash.

Oregon

Edward A. Haas, 6334 N. Missouri Ave., Portland 11, Oreg.

Philadelphia

Linn Edsall, 2301 Market St., Philadelphia 3, Pa.

Pittsburgh

Warren J. Iliff, Equitable Auto Co., 214 N. Lexington Ave. Pittsburgh 8, Pa.

St. Louis

August H. Blattner, Carter Carburetor Corp., 2840 N. Spring Ave., St. Louis 7, Mo.

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San Diego

Jerome J. Wheeler, Jr., 7321 Oakwood Dr., Linda Vista, San Diego, Calif.

Southern California

Charles L. Fernau, Standard Oil Co. of Calif., 605 W. Olympic Blvd., Los Angeles 15, Calif.

Southern New England

Alexander M. Watson, 81 Foxcroft Dr., Manchester, Conn.

Spokane-Intermountain

Peter J. Favre, 10 W. Third Ave., Spokane 8, Wash.

Syracuse

Leslie R. Parkinson, 117 Harrington Rd., Syracuse, N. Y.

Texas

Ross A. Peterson, Texas Trade School, 1316 W. Commerce St., Dallas 8, Tex.

Twin City

Wayne E. Schober, 4620 Columbus Ave., Minneapolis, Minn.

Virginia

Robert P. Knighton, Esso Standard Oil Co., Broad & Hamilton Sts., Richmond 21, Va.

Washington

Hyman Feldman, 3222 M St., N.W., Washington, D. C.

Western Michigan

Thomas Reeves, Continental Motors Corp., Muskegon, Mich.

Wichita

Virgil W. Hackett, 143 N. Fountain, Wichita 8, Kans.

GROUPS

Atlanta

H. M. Conway, Jr., Southeastern Research Institute, Inc., 5009 Peachtree Road, Atlanta, Ga.

Colorado

Kenneth G. Custer, 1216 South Williams, Denver 10, Colo.

Mohawk-Hudson

A. Frank Geiler, Schenectady Railway Co., 121 Erie Blvd., Schenectady, N. Y.

Salt Lake

Stanley W. Stephens, 36 E. Crystal Ave., Salt Lake City 6, Utah.

Williamsport

Carroll S. Townsend, General Armature & Mfg. Co., Lock Haven, Pa.